REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE 1952

UNITED STATES DEPARTMENT OF AGRICULTURE

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REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE, AGRICULTURAL RESEARCH ADMINISTRATION, 1952

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 15, 1952.

DR. B. T. SHAW,
Agricultural Research Administrator.

DEAR DR. SHAW: Consolidation and reorientation of much of our administrative work on a regional basis was concluded during the year. This was accomplished with the least possible disturbance to our program activities. Some of the most serious insect infestations of the previous year have been brought under control. Others have arisen to hamper crop production. Accomplishments of our research, control, and regulatory personnel are summarized in the attached report for the fiscal year ended June 30, 1952.

Sincerely yours,

AVERY S. HOYT,
Chief.

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THIS YEAR IN BRIEF

Major accomplishments of the year included the practical control by an insect predator of the noxious Klamath weed in the California county most heavily infested, the inauguration of a Bureau supervised source-inspection service for Holland-grown bulbs prior to their export to the United States, and the successful colonization in Mexico of parasites that have proved effective in controlling citrus blackflies in some infested areas.

This year's research activities have again demonstrated the important place insecticides hold in reducing the enormous losses of crops, livestock, and stored products caused by insect attack. Departmental estimates are that 252 million pounds of the five major representative insecticides will have been used in crop protection activities throughout the United States for the crop year October 1951 to September 1952. This compares with the consumption of 232 million pounds for this purpose in the preceding year. There was an ample supply of insecticides available for use this year.

Five regional offices were established at the beginning of the fiscal year to handle administrative matters for all Bureau field stations and to direct regulatory and control programs. Substantial progress was made in consolidating and improving laboratory and office building facilities, establishing Bureau-wide uniformity in administrative procedures, and appraising both program and personnel requirements of regulatory and control projects.

Functions of the former Division of Grasshopper Control were re-

organized as a project under the direction of the North Central regional director. Mexican fruit fly control and blackfly control activities were combined under a single project leader responsible to the Southwestern regional director. White-fringed beetle control activities on the Gulf coast and the South Atlantic coast were merged into a single control project.

Better utilization of manpower and equipment was obtained through an extensive exchange of personnel and equipment among projects to meet varying workloads and to take advantage of opportunities for further training of personnel in a variety of activities.

Through consolidation of project offices and suboffices, 376 stations have been reduced to 333 in 288 towns. Further consolidations will be made as favorable opportunities arise.

Improvements in personnel activities were instituted to stimulate employee efficiency, safety, and morale. Emphasis was also given to property and records management, a revised budget and accounting system, and a review of informational policies and editorial standards.

Effective July 11, 1951, Gilbert J. Haeussler was appointed division leader of the Division of Truck Crop and Garden Insect Investigations, succeeding William H. White, deceased. David G. Hall was appointed acting in charge of the Division of Insect Survey and Information, the position vacated by Mr. Haeussler's transfer.

A cooperative insect pest survey and reporting service was organized in April 1952. Entomologists associated with State agencies, industry, and the Federal Government are cooperating in this service—organized for the purpose of keeping the Nation's farmers informed on impending insect conditions. By forewarning farmers of current insect pest conditions, the service will allow them to meet these insect threats as they occur. The survey staff would also provide the skeleton organization required for protection against biological warfare should the need arise. A Section of Economic Insect Detection and Reporting to coordinate this work was organized as a unit of the newly designated Division of Insect Detection and Identification (formerly the Division of Insect Identification). Kelvin Dorward was named head of this section. Carl F. W. Muesebeck continued as leader of the redesignated division. Five experienced Bureau men were selected for service in each of the five regions into which the Bureau's control and regulatory functions are divided. These men work cooperatively with the States to facilitate collection and reporting of insect survey information.

Also in April 1952 there was established a new Division of Bee Culture and Biological Control. This consolidated into a single division all Bureau activities relating to bees and other beneficial insects. This division is also responsible for research relating to biological control of insect pests and weeds. James I. Hambleton, formerly in charge of the Division of Bee Culture, heads the new division.

Paul A. Hoidale retired as leader of the grasshopper control project on May 1, 1952, after 36 years of service. Mr. Hoidale was leader of the Division of Mexican Fruit Fly Control from 1927 until 1950, when he transferred to the grasshopper control project.

A new Division of Stored Product Insect Investigations was organ-

ized on September 10, 1951, with Randall Latta as division leader and Lyman S. Henderson, assistant division leader. This division will conduct research on the control of insects that destroy stored products. A number of such activities that previously had been conducted by other divisions were shifted to the new division.

Bureau personnel continued in a consultant capacity with numerous Advisory Committees interested in a wide variety of insect research investigations. Of especial importance was an industry-wide food advisory committee created to consult with the new Division of Stored Product Insect Investigations.

E. R. Sasscer, in charge, Division of Plant Quarantines, was the delegate of the United States to the International Plant Quarantine Conference sponsored by the United Nations Food and Agricultural Organization at Rome, September 25 to 27, 1951. Along with representatives of 23 other governments he participated in the preparation of a revised draft of the International Plant Protection Convention. This convention has the objective of preventing the spread of plant pests and controlling them on an international basis. Frank McKennon, Chief, Division of Plant Industry, Oregon State Department of Agriculture, attended as alternate delegate.

Several additional all-time records were established in the number of inspections of foreign plant material arriving at United States ports and in inspections of pedestrians entering from Mexico.

A number of entomologists transferred from the Bureau during the year to foreign assignments on Point IV programs. Other former Bureau personnel continued their foreign assignments with the Department of State on important desert-locust-control activities in the Near East.

Bureau specialists completed the preparation of scores of manuscripts and colored illustrations for the Department's 1952 Yearbook of Agriculture on "Insects."

A study group was appointed by Secretary of Agriculture Charles F. Brannan in September 1951 to review the insect and plant disease programs of the Department and to make recommendations thereon. This committee had the cooperation of State and land-grant college officials, farmers, representatives of producer and industry organizations, and others who appeared at hearings or submitted statements. After a thoroughgoing review, the study group submitted its report and recommendations on February 1, 1952. This report was in turn transmitted to the Subcommittee on Agriculture of the House of Representatives Committee on Appropriations. The report contained many constructive recommendations indicating the ways in which essential control programs may be performed most effectively and efficiently. It was possible to carry out some of these recommendations during the current fiscal year. Other recommendations will influence future operation of these activities.

Plans are being made for the celebration in 1954 of the one hundredth anniversary of entomology in the Federal Government. On June 14, 1854, an entomologist was added to the staff of the United States Patent Office. A committee has been appointed to prepare a tentative program for the recognition of that event.

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FRUIT AND NUT INSECTS

Citrus Blackfly Investigated

Indian citrus blackfly parasites show remarkable buildup in Mexico

The relative importance of the four Indian parasites, introduced into Mexico as part of the Bureau's cooperative work with Mexican authorities for control of the citrus blackfly, has changed considerably over that of the previous year. Last year *Prospaltella smithi* was the only parasite that showed any promise. In the latter part of 1951, *Amitus hesperidum* and *P. clypealis* increased very rapidly and showed evidence of dominating *P. smithi*. A fourth parasite, *Prospaltella* sp. near *opulenta*, was set back considerably by having its two colony sites destroyed by the destruction of the trees on which they were established. In June 1951 a small number of adults was seen in a grove about 1 kilometer from one of the colony sites. Here the parasite has been slowly increasing. *P. smithi* increased considerably in certain groves near Matlapa in the Valles region and in Cuernavaca. In one grove in Matlapa it increased steadily during the dry season from October to June. Good commercial control was obtained there 10 months after the original release. More than 1,700,000 adults of this parasite were colonized in practically all of the blackfly-infested citrus areas of Mexico.

Of all the Indian parasites now established in Mexico, *Amitus hesperidum* has shown the most remarkable buildup and parasitization. It required about 1½ years to adjust itself to its new environment. During this time parasitization ranged from 1 to 10 percent. Beginning in June 1951 this parasite began to increase considerably in the Valles and Morelos areas. By December parasitizations of from 80 to 90 percent were obtained in some groves. An estimated 124,000 adults of this species were liberated in the various citrus growing areas, mostly in the north. The development of *P. clypealis* in Mexico closely parallels that of *Amitus*. Approximately 258,000 adults of the former species were collected between August and December 1951 and colonized in most of the citrus regions, especially in the areas of infestation nearest the United States. *Eretmocerus serius*, introduced into Mexico a few years ago, continued to exert a fairly high degree of parasitization in the more humid or wet areas along the West Coast, but appears to be of little consequence in the dry areas.

Citrus blackfly surveys

Citrus blackfly surveys, begun in the fall of 1949, were continued along the Mexican border during 1951 in the States of Nuevo Leon, Tamaulipas, San Luis Potosi, and Baja California. Most of the survey work has been done by Mexican nationals, working with Bureau personnel. From light to heavy infestations were found in each State, with the exception of Baja California. The blackfly is established even there, but at points remote from the northern part of the State. These surveys are for the purpose of preventing the introduction of this insect into citrus groves in the United States. The pest is considered one of the most dangerous and difficult to control of all citrus insects. It was introduced into Mexico about 1936.

Expenditures by the Mexican Blackfly Committee in the States of Nuevo Leon, Tamaulipas, and San Luis Potosi are at the annual rate of $250,000. These funds are raised through direct taxation on citrus plantings and gasoline sales.

When an infestation is found by a Mexican survey crew, the control and eradication activities are promptly taken over by the Mexican Department of Agriculture and the Mexican Blackfly Committee. As a result of this closely coordinated program several hundred incipient blackfly infestations have been found. All of them have been either eradicated or greatly reduced in numbers.

It is anticipated that these intensive surveys of border areas in cooperation with the Mexican authorities will prove so effective in suppressing infestations that the fly's introduction into American citrus groves may be postponed indefinitely, at least until such time as well established parasites can effect practical control.

Texas nursery inspectors are making detailed citrus blackfly inspections along with their other duties. Inspectors of the California Department of Agriculture are also on the lookout for this pest.

Sterilization of blackfly infested citrus studied in Mexico

Dips to destroy the citrus blackfly in packed limes were tested in Mexico, in cooperation with the Mexican Secretaria de Agricultura y Ganaderia. Lime leaves infested by the citrus blackfly had been found in boxes of packed limes shipped to the United States. There is a considerable trade in limes. A dip with oils of high paraffinicity and viscosity (oils used for processing wool) gave complete mortality in tests using more than 100,000 blackfly pupae. It was necessary, however, to develop a formula that would kill both the citrus blackfly and the Florida red scale. The oils used were not fully effective against the scale. Work was therefore shifted to red scale. Exploratory formulae look promising but no completely satisfactory dip for these two insects is yet available.

Wild citrus may be significant item in citrus blackfly infestation in Mexico

The relative abundance of blackfly infestation in wild land in Mexico has been shown to depend on wild citrus. In moist years the blackfly persists on noncitrus plants in the wild, but in drought years only on wild citrus. Fortunately, wild citrus has not been found in northern Mexico. In 1951, because of drought conditions, infestation in wild areas disappeared unless maintained by wild citrus. This year with ample rains it has persisted.

Citrus blackfly control treatments effective

In the San Luis Potosi area of Mexico citrus blackfly infestation is general and heavy. Cleanup would be financially impossible. Experiments have been directed to commercial control, to tests of trees for tolerance to spray treatments, and to large-scale tests of promising insecticidal formulations. In one grove commercial control experiments involving two spray applications doubled production during the year. In another the crop was trebled by two applications. Commercial control has made crops profitable.

In tests on large plots a new modified xylene-oil-DDT formula gave

virtual cleanup with five applications and without tree injury. Speed-sprayer tests showed that an application of the xylene-kerosene-DDT formula followed in 30 days by an application of an oil-cubé formula was better than the reverse order previously used. Using the oil formula last also cut down the buildup of scale. Experiments showed that formulae with DDT or parathion are most effective at the peak of adult emergence, the oil-cubé formula 1 month later; hence the reversal of the previous system.

ORIENTAL FRUIT FLY INVESTIGATED

Bioclimatic cabinets furnish valuable information on oriental fruit fly behavior

Seven walk-in type cabinets for the study of the effect of climatic conditions on the oriental fruit fly are now in operation in Honolulu. This study is being carried on jointly by the Bureau and the University of California Agricultural Experiment Station.

Each cabinet provides an interior working space measuring 6 x 6 x 6 feet and is capable of controlling temperature through a range of from −5° to 125° F. with an accuracy of plus or minus 1° F. Relative humidity in 6 of the cabinets can be controlled through a range of from 20 to 95 percent at temperatures from 35° to 125° F.; in the seventh humidity can be controlled at subfreezing temperatures. Ultraviolet and infrared lights simulate very closely the radiant energy and natural light of the sun. Flies are contained in globular screen cages. Adult flies have access to synthetic materials and natural food to assure development of sexual maturity and for maximum productivity, fertility, and length of life. Daily mortality counts are made.

Temperature and humidity conditions representative of the climates of Oceanside, Fresno, and Riverside, Calif.; Charleston, S. C.; Fort Pierce, Fla.; and Vincennes, Ind., were simulated in the initial cabinet studies.

Results of 1 year of continuous operation of the cabinets show that the lowest average temperature at which the eggs or larvae of the oriental fruit fly can develop is about 57° F., that average temperatures above 70° are necessary for the fly to attain sexual maturity without the preoviposition period becoming unduly extended, and that areas with twilight temperatures lower than 60° may impose limitations on the mating of the oriental fruit fly which usually copulates only at dusk. Temperature at which the fruit fly was able to reproduce efficiently ranged from 65° to 80°. It was learned that the growth of the fruit fly was more rapid when subjected to fluctuating temperatures than in constant temperatures. Fruit flies were able to survive and reproduce for at least part of a year's climatic cycle corresponding to that of each of the localities simulated.

The Vincennes climate provided the shortest period favorable for egg-laying and reproduction and consequently it was the least acceptable climate for fruit fly establishment. The length of the period favorable for reproduction during the simulated year was progressively longer in the cabinets representing conditions at Riverside, Oceanside, Fresno, Charleston, and Fort Pierce. In comparison

with the other climates, the Fort Pierce simulation possessed the most nearly ideal meteorological conditions for development of this species. Almost year-round reproduction took place, a fourth generation being completed late in the winter.

Climatic conditions that may adversely affect fruit fly development or that may be fatal to established infestations, are part of a continuous study with these chambers.

Climate limits fruit fly development

Eleven stations at elevations ranging from sea level to 9,200 feet on the islands of Maui and Hawaii, have furnished sufficient data to indicate in some measure the limitations imposed by climate on the development of the melon fly and the oriental and Mediterranean fruit flies.

Adult fruit flies were able to live for extended periods under cool temperatures; sometimes for more than a year. In mainland areas where similar conditions prevail during winter periods, the flies should be able to survive and later produce progeny when temperatures become more favorable.

The oriental fruit fly showed higher survival in areas with temperature peaks high enough to permit some development than it did in areas where the temperature held within a narrow range near the survival threshold.

Of the three species of flies, the melon fly was able to tolerate greater extremes of temperature and relative humidity. It developed at lower temperatures than did either the Mediterranean or oriental fruit flies.

Longevity studies showed that all three flies may survive long enough to bridge 2- or 3-month periods when no fruit is available to them. After surviving in cool areas for more than a year, melon fly females were still able to produce eggs that hatched.

Traps determine intensity of fruit fly infestations

Intensity of oriental fruit fly infestations on Maui, Hawaii, and Oahu were determined by means of glass traps baited with methyl eugenol, citronella or with fermented lures by the Bureau and the University of Hawaii. Peaks of infestation again proved to be invariably correlated with periods of greatest abundance of fruit.

The infestation on Oahu was greatly reduced from the original peak infestations. There were also fewer flies on Maui and Hawaii as a result of the work of the parasites. Nevertheless substantial infestations in preferred fruits demonstrated that a serious though less severe problem persists.

Foreign parasite introduction program completed in Hawaii

The introduction of parasites into Hawaii from foreign countries, initiated as a cooperative project in 1948, was brought to a close in the fall of 1951 with the return to the United States of the last two explorers, one from Africa and the other from southeast Asia. During 1951 nearly 150 shipments containing more than 1 million fruit fly puparia were received in Hawaii from East and West Africa, South India, Siam, North Borneo, Fiji, Java, Ceylon, and Brazil. From

these puparia a large number of parasites were reared. Approximately 150,000 adults, representing more than 20 species of parasites, were liberated by the Territorial Board of Agriculture and Forestry in various localities in the islands. It is now known that several species of parasites are definitely established.

Effective insecticides for oriental fruit fly control developed

In small plot tests on guava, parathion applied at the rate of 2 pounds an acre at biweekly intervals in a dilute spray gave 100 percent control of the oriental fruit fly up to 6 days after each of 6 sprays and 96 percent control during the second week. Unsprayed fruit averaged 5 larvae in a pound. DDT at the rate of 4 pounds gave 94 to 95 percent control; dieldrin at the rate of 2 pounds 97 percent; and aldrin at the rate of 2 pounds 86 percent. CS–708 was 90 percent effective. A bait spray containing raw sugar, 10 pounds, and protein hydrolysate, 2 pounds, plus 1 pound of parathion an acre, was 81 percent effective when applied to scattered guava trees.

In another 14-treatment test on bananas a similar bait spray formula, with only 9 ounces of parathion applied per acre, was the outstanding treatment, giving a 93 percent reduction from unsprayed plots in which infestations ranged from 2 to 24 larvae per pound.

In semi-isolated gulches, where approximately 28 acres of guava were sprayed at 3-week intervals, a bait spray with only 4 ounces each of parathion and protein plus 5 pounds of sugar an acre gave 91 percent control, as compared to 82 percent where DDT was used at the rate of 1.5 pounds an acre. Bait sprays utilizing low concentrations of parathion were most effective when used on plots of 2 or more acres.

In these and other special tests there was further evidence that dieldrin attracts ovipositing females from adjacent areas; also that it kills the flies too slowly to prevent some infestation.

Evaluation made of large-scale fruit fly control experiment on Lanai

After the completion on Lanai of the treatment schedules on March 20, 1951, oriental fruit fly infestations remained at exceedingly low levels until September, primarily because of lack of suitable fruit. During September and the first 2 weeks in October normal increases were noted. These observations confirmed previous conclusions that the reduction of flies almost to the vanishing point during the treatment period was entirely the result of the aldrin, DDT, parathion, and other area control treatments that had been applied, and that with continued treatments eradication of an isolated infestation is entirely feasible. This work has now been concluded.

Low temperatures studied as a means of ridding fruits and vegetables of fruit fly infestation

Low temperatures from 30° to 45° F. were studied as a means of destroying fruit fly infestation in various commodities. To date 142 experiments have been conducted with 14,700 fruits and vegetables containing approximately 213,000 fruit flies. The number of days required to kill all stages of the oriental fruit fly ranged from 9 days at 30° to 10 days at 37°, and from less than 14 days at 40° to more

than 28 days at 45°. Complete kill of the melon fly was obtained after 7 days at 30° and 10 days at 37°. The low temperature storage thresholds for most Hawaiian fruits and vegetables are above 45°. This would prevent the use of a cold storage treatment except for snap beans, bell pepper, and possibly some varieties of avocado. However, cold storage might be useful for many mainland fruits such as citrus, grapes, apples, and pears, which withstand long storage periods at the experimental temperatures.

Mexican Fruit Fly Control

Although practically all of the citrus trees in Texas were severely damaged and many of them were killed outright during the freeze of January 1951, those which remained made rapid progress toward recovery. There was a small fruit crop produced in the Mexican-fruit-fly-regulated area. This light fruit production made it possible to reduce field activities considerably. It was necessary to continue those activities that are essential to control the Mexican fruit fly and prevent its spread. Accordingly, traps were operated and inspections were made in Texas where warranted. Fruit was moved from the regulated area under the same type of supervision as during former seasons.

During the season 1,400 groves were inspected for larval infestations. About 2,000 traps were operated continuously throughout the regulated area. More than 62,000 fly trap inspections were made. Ordinarily, several hundred larval infestations are found each year and thousands of fruit flies trapped. During this period, however, due to the scarcity of the fruit and an early harvest, no larval infestations were found. Only a few fruit flies were trapped.

Particular emphasis was placed on inspection of fruit being shipped to other fruit-producing areas, such as Arizona and California. Fruit designated for shipment to these States was inspected tree by tree before harvesting. Fly traps were operated in the vicinity of each grove to make doubly certain that no infested fruit was being moved which might cause an infestation in another fruit-producing State.

The short citrus crop in Texas allowed the assignment of personnel to operate fruit fly traps in the small but important Louisiana citrus area. Men were also available to conduct some needed exploratory work along the Mexican border in the States of Tamaulipas, Sonora, and Baja California. These surveys were in localities adjacent to the citrus plantings in Texas, Arizona, and California.

Along with their other duties, Mexican fruit fly inspectors were able to inspect 1,945 citrus plantings in the lower Rio Grande Valley for possible infestations of the citrus blackfly. No such infestations were found there.

Parasites Survive DDT Sprays

Further field studies were made of the effectiveness of the predaceous coccinellid beetle *Stethorus punctum* following DDT spray applications in apple orchards at Yakima, Wash. These studies confirmed the observation, first made in 1950, that this species can survive two applications of DDT and still recover sufficiently to prevent late season economic damage by host mites.

Miticides Compared in Orchards in Pacific Northwest

Mites on which acaricides were tested in the Pacific Northwest included the clover mite, European red mite, two-spotted mite, Pacific mite, and the yellow mite *Tetranychus borealis* Ewing. A minimum of ¾ pound of 15-percent parathion to 100 gallons of water was necessary for good control of mites. Malathon gave a satisfactory control, but is somewhat less effective than parathion at comparable dosages. EPN was fully as effective as parathion; Metacide somewhat less effective. Of the compounds tested which do not contain phosphorus, DMC (Dimite) was the most effective and long lasting. A single application in June controlled all species for the rest of the season. *P*-chlorophenyl *p*-chlorobenzene sulfonate (Ovotran) gave poor control of the Pacific mite, but excellent control of the other species. R–242 (Sulphenone) gave limited control of the Pacific mite and yellow mite but satisfactory control of other species. It was particularly lethal to the predacious mite *Iphidulus*. Aramite, used at ½ and ¾ pints to 100 gallons, did not control the clover mite or Pacific mite well, but gave good control of the other species. At 1½ or 2 pints it should give satisfactory control. CS–708 (Dilan) had little value against orchard mites but was very toxic to the predacious mites and insects.

The appearance of resistant mites in the Yakima Valley provided an opportunity to investigate their control. A strain of the European red mite that had survived three applications of parathion was controlled with EPN. In small tests, good control was also obtained with R–242, Aramite, and *p*-chlorophenyl *p*-chlorobenzene sulfonate, the latter being particularly effective. A strain of the Pacific mite that had resisted parathion was effectively controlled with Aramite, and also succumbed to malathon and DMC.

Plum Curculio Control Effective but Complicated by Objectionable Residues

The outstanding insecticide tested against the plum curculio on peach in Georgia in 1951 was dieldrin. This material gave a high degree of control in an unusually severe infestation, the experimental trees being exposed to continual reinfestation from an adjacent unsprayed block that was severely infested. Under these conditions, several other treatments that usually give satisfactory results fell down completely. Unfortunately, residues of dieldrin are now regarded as excessively dangerous, and a full schedule of this material will undoubtedly give objectionable residues. For this reason it is likely that dieldrin can be used in only two or three early-season spray applications. In other Georgia experiments carried on in a moderately infested peach orchard, satisfactory control was secured with dieldrin and several other materials, including parathion, EPN, and aldrin.

Tree Injury Results in Withdrawal of Recommendation for Peach Borer Control

For the first time in 11 years of work with propylene dichloride emulsion for the control of the peach tree borer, injury to trees resulted from the recommended dosage of one-half pint of

10-percent emulsion per tree. This injury evidently resulted from the fact that the soil was unusually wet during the fall of 1950, when the applications were made. Since such conditions are occasionally encountered by peach growers applying the material, the injury that developed in 1950–51 appears sufficient to justify the withdrawal of recommendations of propylene dichloride emulsion for control of the peach tree borer.

In experiments in Georgia with sprays, good results in reducing the borer infestation were obtained from DDT (50 percent) or benzene hexachloride (6 percent gamma isomer) at the rate of 8 pounds per 100 gallons of water applied to the trunk and lower part of large limbs of peach trees three times at 5-week intervals starting August 1, during the egg-laying period of peach borer moths.

The results of experiments on peach nursery stock conducted in Georgia in 1951 indicate that benzene hexachloride alone or a combination of DDT and parathion is more effective than parathion alone for preventing peach tree borer infestation in peach nursery stock.

Field-plot experiments were performed in Indiana to test methods of controlling the lesser peach tree borer. Heavy reductions in numbers occurred when four spray applications were made at 21-day intervals, starting June 15, with either parathion (15 percent) at 3 pounds to 100 gallons or EPN (25 percent) at 2 pounds to 100 gallons. Reductions in the number of applications or the concentration resulted in reduced control. Little or no control was obtained with lindane, dieldrin, or DDT. Single applications of post-harvest sprays did not reduce lesser peach tree borer injury.

New Oriental Fruit Moth Parasites Reared

Two new Chinese species of oriental fruit moth parasites, received through the California Citrus Experiment Station, were propagated successfully on the oriental fruit moth in small green apples during the year. Routine breeding and colonization were started. About 42,000 of one species, *Agathis* n. sp., and 39,000 of the second species, *Phanerotoma grapholithae* Mues., were reared in 1951. Colonization of the two new Chinese species of oriental fruit moth parasites was for the purpose of establishing them to supplement native species. These new species, which have shown ability in attacking fruit-infesting stages of the fruit moth not now heavily attacked by the native species might prove to be highly valuable. North Carolina and New Jersey received a large proportion of all parasites available for liberation in 1951. The North Carolina Agricultural Experiment Station cooperated in making liberations in that State. There were 210 separate releases of about 26,000 *P. grapholithae* and 178 releases of about 21,000 *Agathis* n. sp. In addition, several thousand of these two species and *Horogenes* were sent to the California Citrus Experiment Station to colonize on the oriental fruit moth in Orange County, Calif.

Spider Mites and Mealybug Controlled on Grapes

Spider mites, *Tetranychus bimaculatus* Harvey or *T. atlanticus* McGregor, on grapes were controlled effectively in Ohio by two applications, 6 days apart, of a spray containing one-half pound of 15-percent parathion or 25-percent EPN, or 2½ pounds of a DDT-para-

thion powder containing 3-percent parathion per 100 gallons; or of a dust containing 1 percent parathion. Inclusion of Bordeaux mixture in the second application did not decrease the effectiveness of the materials against the mites.

A single application of DDT in combination with 1 pound of 15-percent parathion or 25-percent EPN, or 2½ pounds of 3-percent parathion per 100 gallons gave an acceptable degree of control of the grape mealybug and of another mealybug, *Ferrisiana virgata* Ckll., when applied while second-brood crawlers were active on the grapes. Chlordane was ineffective.

Newer Miticides Tested Against Citrus Red Mite

As part of the work to develop better methods for controlling mites that infest citrus, special consideration is being given to the citrus red mite. In California, *p*-chlorophenyl *p*-chlorobenzene sulfonate (Ovotran) at 8 pounds per acre was one of the best of the newer acaricides and had considerable commercial usage. Control by parathion was of short duration. Results with parathion plus Ovotran varied in different locations. In some cases the combination was as effective as the full dosage of oil. In one experiment, benefits from the addition of Ovotran were of short duration. The combination of 1 percent of oil plus parathion was superior to larger amounts of parathion alone.

Work in Florida sought to develop hot-weather combination sprays that would be less expensive than the separate oil emulsion sprays formerly necessary for red mite control. The new miticides bis-(*p*-chlorophenoxy) methane (Neotran), R–242, EPN, *p*-chlorophenyl *p*-chlorobenzene sulfonate (Ovotran), compound 923, and Aramite were found to be effective for control of the red mite on Temple orange trees in April or in May. These were compatible with basic copper sulfate fungicide, with wettable parathion, and with wettable sulfur. They were more effective in dry weather. Oil emulsion spray gave better control when heavy rains followed the applications.

Marked increases in red mite infestations followed sprays of Metacide plus wettable sulfur or parathion plus wettable sulfur applied late in March. Inclusion of bis(*p*-chlorophenoxy) methane in June combination sprays containing wettable sulfur or parathion plus wettable sulfur controlled these heavy infestations on Ruby grapefruit trees.

Physiological Study of Red Scale Discloses Resistance Factors

Investigations of the reactions of different strains of California red scale to HCN and other gases were made to find the physiological basis of resistance to HCN. Resistance of some strains has increased until satisfactory control cannot be obtained with dosages that the tree will tolerate. Resistance was not caused by tracheal closure on exposure to HCN. Resistance was associated with a difference in the respiratory enzyme systems, susceptibility being dependent on a heavy metal-containing respiratory enzyme system and resistance on metal-free enzymes, possibly of the flavoprotein type. These findings, which came after a long series of studies, offer an explanation of the physiological basis of one of the earliest known and most studied cases of insect resistance to an insecticide.

European Chafer Attracted to Chemically Baited Traps

In tests to find an effective chemical attractant for the European chafer, a 3 : 1 mixture of Java citronella oil and eugenol gave the best results. Traps painted Chinese red were slightly more effective than black or other colored traps. Traps baited with Java citronella oil caught more beetles than did traps using live, laboratory-reared virgin female chafer beetles, field-collected female beetles, or extracts from female beetle abdominal tips. The Cornell June beetle trap, larger than the standard Japanese beetle trap, caught more beetles than any of the Japanese beetle traps. Painting the baffles of traps with automotive grease (ordinary high-pressure chassis lubricant) increased the catch in all types of traps over ungreased traps. Standard Japanese beetle traps painted black and with the baffles greased, set up singly at points along the periphery of the infested area, caught a few beetles in areas where the infestation was known to be extremely light.

Chemical Treatment of Nursery Stock Destroys European Chafer

During the fall of 1951 a schedule was developed for the treatment of large nursery trees with an ethylene dibromide-chlordane mixture applied as a fumigant. The principal requirement of this schedule is an application of 40 milliliters of the ethylene dibromide-chlordane concentrate in 1 gallon of water to each square yard of soil surface around the tree. This is done 5 days before the tree is dug and at a temperature of 50° F. or above. Trees treated in this manner in the fall are safe for movement to points outside the European-chafer-infested area. Similar treatments applied in the spring did not kill all the grubs, which by that time were nearly full grown.

Quicker Vapor-Heat Process for Citrus Fruit Sterilization Developed

Improvements have been sought in the vapor-heat method of sterilizing citrus fruits to destroy any fruit fly infestation before their certification to uninfested areas. The work has been done in the Mexico City laboratory in cooperation with the Mexican Secretaria de Agricultura y Ganaderia. This method involves heating the citrus to a designated temperature by saturated vapor for a specific period. It has been used in Texas for the sterilization of one-half million tons of citrus for markets that otherwise would have been closed to the fruit. The objective of the present work is to develop a much quicker process by use of higher temperatures. Records obtained on an estimated 2,800,000 larvae in more than 40 tons of infested fruit indicate that sterilization of fruit with a quick runup of the temperature to 115° F. in a period of not less than 4 hours will give adequate security against fruit fly survival.

More Tree-Owner Participation in Hall Scale Control Obtained

Removal of host seedlings from waste areas, initiation of a more active voluntary host-removal program, tree fumigation, and application of two oil sprays to suppress Hall scale infestation continued in 1951 as measures to eradicate this introduced and potentially serious pest of peaches, almonds and related hosts. The scale is known to

occur only in a limited area in and near Chico and Davis, Calif. The control work is cooperative with the California Department of Agriculture. Although an extensive survey was made during the year, additional live scales were found only in areas near previously infested plantings. Infestations involving 1,600 additional trees were discovered in these nearby areas.

Approximately 4,000 trees were fumigated, 1,280 for the third and last time unless scales are found on them later. Because of unfavorable weather conditions, about 2,000 trees remain to be treated.

Owing to a reduction of staff, the 1951–52 fumigation program was resumed in October with only a single crew. More than 2,200 trees had been treated by the end of 1951.

Inspectors making a routine inspection of host plantings along the border of the old University of California campus at Davis, found three infested hosts on two adjoining properties, about 1,000 feet from the site of the infestation that was eradicated several years ago. These infested trees and other hosts in that locality were sprayed with the usual 2-percent soluble oil solution. Future operations contemplate resumption of fumigation activities in this immediate area.

TRUCK-CROP AND GARDEN INSECTS

Insect Contamination Problems of Canners Studied

Studies are being carried on under Research and Marketing Act funds to determine what problems of insect contamination exist in plants processing vegetables and small fruits, and to devise the steps that may be taken for solving them. The problems which appear to be of concern to canners include: Aphids, corn earworm, a bud maggot, and certain caterpillars on leafy vegetables; aphids and certain caterpillars on broccoli and Brussels sprouts; aphids on celery; vinegar gnats, thrips, mites, and the tomato fruitworm on tomatoes; asparagus beetle eggs and thrips on asparagus; and thrips and mites on berries. Twenty-eight canning and processing plants were questioned in Oklahoma, Arkansas, Texas, California, and Utah in 1951. None of these had in use satisfactory methods for removing insects from crops to be processed. Most processors stated that when an insect infestation is serious enough to indicate that the pack would be contaminated with insects or insect fragments it is their practice to reject the crop for packing purposes.

In research under way at Beltsville, Md., encouraging results are being obtained in the development of washes for removing asparagus beetle eggs from asparagus being processed. Promising results are also being obtained with several dips or washes for removing aphids from broccoli. Limited progress has been made on studies of dips to remove the larvae of European corn borer from ears of sweet corn. The objective of these studies is to develop practical methods whereby the processor, through a minor modification of his usual washing process, can free the particular product being processed from insect contamination. The availability and adoption of such methods will have the added advantage of benefiting the grower since it will permit the acceptance of infested produce which otherwise would be rejected.

Sweetpotato Weevil Control

Sweetpotato planting restrictions, originally imposed because of sweetpotato weevil infestations, were removed from 2,050 farms after thorough inspections failed to locate any further infestation. First-record infestations of this most destructive pest of sweetpotatoes were found on 1,140 properties throughout the infested area. Suppressive control measures were applied on 20,000 farms in 6 Louisiana parishes.

Only half as many infested properties were found in 1951 as in 1950. Active infestations were reduced by 20 percent in the infested parts of Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas.

DDT dusting of seed sweetpotatoes in the control areas of Louisiana progressed to the extent that approximately 80 percent of the growers applied this treatment.

Bureau personnel continued to assist infested States in the enforcement of quarantines to prevent the spread of the weevil to noninfested areas or its reintroduction into areas from which it has been eradicated. Weevil infestation in sweetpotatoes intended for shipment has been greatly reduced by more effective cultural methods, together with enforcement of sanitary procedures and DDT spraying at kilns and packing sheds. Certified shipments from Louisiana alone during 1951 totaled approximately 6 million bushels. Fewer violations of the State regulations were reported, indicating a greater public acceptance of the precautionary requirements.

Curly-Top Disease in Beans Reduced by Killing Beet Leafhoppers on Wild Hosts

Research was started in 1948 to determine whether the seed bean crop in southern Idaho can be protected from curly-top disease by controlling its vector, the beet leafhopper. This leafhopper concentrates and develops on weed host plants growing on the desert and on idle and waste lands. The work was done in cooperation with the Idaho Agricultural Experiment Station with funds authorized under the Research and Marketing Act.

Host-plant surveys were made in southern Idaho during the fall of 1950 and early spring of 1951. These surveys indicated that approximately 6,300 acres of weed host plants were infested by the beet leafhopper to an extent that made this acreage potentially dangerous as a source of infestation by adults migrating to adjacent or nearby bean fields. Consequently, this entire acreage was sprayed during the period April 28 to June 9, 1951, with a concentrated emulsion spray containing DDT. The spray was applied with turbine blowers, equipped with side-delivery nozzles, mounted on trucks, at the rate of approximately 2 gallons per acre, which gave about 0.6 pound of DDT per acre. A post-treatment survey disclosed that beet leafhopper numbers in the weeds had been reduced about 93 percent. Examinations in southern Idaho during mid-season of fields of garden beans grown for seed showed that the number of bean plants infected with curly-top disease had been reduced from an expected 12 percent to an observed 3.9 percent. This percentage was calculated from an index

of expected injury based upon studies of factors affecting beet leafhopper populations during the 10-year period 1941–50. Since the conditions of this experiment required that all of the heavily infested weed areas be treated with the insecticide, it was not possible to leave an untreated area of such weeds to serve as a check.

Similar results had been obtained in 1950. As a result of spraying approximately 15,000 acres of the spring breeding areas with DDT emulsion, the number of bean plants infected with curly-top disease in 1950 was reduced from an expected 17.2 percent to an observed 9.6 percent.

It has thus been demonstrated in two consecutive years that the application of a DDT emulsion spray to heavily infested weed host plants in breeding areas of the beet leafhopper in southern Idaho will reduce the numbers of this pest sufficiently to result in an important decline in the percentage of garden bean seed plants infected by curly-top disease in adjacent or nearby areas. Satisfactory equipment and methods for applying the insecticides were also developed. Since the research objectives of this project appear to have been accomplished, the work was discontinued in the fall of 1951.

Control of Beet Leafhopper on Sugar Beets Requires Proper Timing

Two series of experiments were carried on in southern Idaho on the direct control of the beet leafhopper on sugar beets. The first series, consisting of five experiments, was designed to protect sugar beet plants from curly-top infection during the seedling stage, the period of greatest susceptibility. DDT was the only insecticide used, and it was applied at a dosage of 1.5 pounds of toxicant per acre, per application, in 30 gallons of spray. The number of applications ranged from 2 to 6. The average gains in yields of sugar beets, over the checks, as a result of the insecticide treatment for experiments 1 to 5 were 1.1, 2.5, 1.1, 1.6, and 1.3 tons, respectively, per acre. The monetary value of this increase at $13 per ton for beets amounted to $14.30, $32.50, $14.30, $20.80, and $16.90, respectively, per acre. A study of the results disclosed that there seemed to be no correlation between the number of applications and increased yields. Evidently the timing in relation to the movement of leafhoppers into the beet fields was more important than the number of applications.

The second series of experiments to control beet leafhoppers on sugar beets was designed to reduce spring-generation beet leafhopper populations at the peak of their movement from their breeding areas to the beets. DDT was applied at a dosage of 2.4 pounds of toxicant in 5 gallons of spray per acre in two beet fields. The heavy flight of beet leafhoppers into the beet fields occurred from June 11 to 20, when 84 percent of the leafhoppers moved in. The timing of the insecticide application was near the peak of the movement. The average gain in yield of sugar beets, over the check, as a result of the insecticide treatment in both fields, was 2.9 tons per acre. The monetary value of this increase at $13 per ton for beets amounted to $37.70 per acre.

Beet Leafhopper and Associated Curly-Top Disease Controlled on Cantaloups

Experiments in Arizona on the beet leafhopper as a pest of cantaloups showed that when leafhoppers infected with curly-top disease feed on cantaloup plants in the cotyledon or two-leaf stage of development, the plants usually die. Feeding of these insects on cantaloup plants in the four-leaf stage of development caused severe stunting of these plants resulting in very low yields. Plants fed upon in the six-leaf stage or later were only slightly retarded in growth, followed by a slight reduction in yield. In some cases there was also a slight reduction in the sugar content of the melons produced on affected plants. The investigations showed that there is a definite relationship between the occurrence of certain species of weeds in cantaloup fields and the prevalence of the beet leafhopper and the curly-top disease in such fields. These weeds are known to be preferred hosts of the beet leafhopper. It was shown further that in cantaloup fields where clean cultural practices were followed to destroy these species of weeds the beet leafhopper populations and resultant curly-top disease remained at a low level.

In further experiments in Arizona, wherein various insecticides were tested against the beet leafhopper on cantaloups, it was found that DDT and parathion dusts are effective against the leafhoppers as well as against associated infestations of thrips. The application of DDT, however, often caused an increase in the populations of spider mites and leaf miners on the treated cantaloups, and also caused a reduction in the number of parasites and predators of the leaf miners and red spiders. In view of these complications a 2-percent parathion dust is now being recommended for beet leafhopper control.

Seed Treatment Effective Against Seed-Corn Maggot

Research in California and Idaho on the biology and control of the seed-corn maggot as a pest of beans showed that three types of seed treatment—dry coating, wet treatment in the form of a slurry, and spraying an insecticide in the furrow simultaneously with the seed-planting operation—were effective against this insect. Aldrin, chlordane, dieldrin, and lindane were used for the purpose. All of the treatments caused injury to the sprouting seed under conditions of high soil moisture, high soil alkalinity, or deep planting. The spray method appeared to be safest, due to lower and more uniform concentration of the insecticide in contact with the seed. The fungicide Arasan was found to be safer than Spergon when used on the seed in combination with an insecticide. Studies on other phases of this problem disclosed that fields where cover crops, manure, or refuse from preceding crops are plowed under are attractive to seed-corn maggot flies until this organic matter disintegrates, indicating that these materials should be plowed under several weeks before beans are planted.

Several Insecticides Control Cabbage Looper

Studies of the utility of DDT and other insecticides for the control of cabbage caterpillars in previous years have showed that a dust containing 3 percent of DDT is effective against most of the species attacking cabbage in the South. Use of DDT for this purpose during the early stage of plant growth is now recommended and has usually given satisfactory results when properly applied. Reports were received from several growers in South Carolina during the fall of 1951 that DDT was not giving adequate protection against the cabbage looper in commercial plantings of cabbage. Field plot tests to check these reports showed that dusts containing 5 percent of toxaphene or TDE were superior to a DDT dust of equal strength against a well-advanced infestation of the cabbage looper. This was the first time that DDT proved inferior to any other insecticide in the control of the cabbage looper in experimental tests in the South. Further observations will be made to determine whether or not this may be an indication that the insect has developed some degree of resistance to DDT following its widespread use on cabbage in recent years. Since many cabbage growers obtained a satisfactory control of the cabbage looper with DDT, it is believed that other factors also were involved.

Complications in Control of Aphids on Cabbage

The cabbage aphid was more abundant in the spring of 1951 than at any previous time in the past 20 years and caused serious damage to many commercial plantings of cabbage and related crops. Extensive observations made on 19 farms in South Carolina showed that growers used parathion, TEPP, BHC, or nicotine to combat this aphid. Parathion was the chief material used and gave an excellent initial kill when properly applied but there was a rapid reinfestation when parathion or TEPP were applied. A nicotine dust gave variable and unsatisfactory results. There were strong indications that the unusually severe infestations of the cabbage aphid were due to the destruction of insect enemies of the aphid by early applications of parathion.

In field experiments for the control of aphids on cole crops in South Carolina, parathion proved superior to nicotine sulfate in the control of the turnip aphid on young cabbage. An intermediate degree of control of this aphid was obtained in the experiments in which lindane and TEPP were used.

Effective Controls for Pea Aphids and Pea Weevils Developed

Large-scale field experiments were conducted during 1951 in cooperation with the Wisconsin Agricultural Experiment Station to evaluate DDT and other new insecticides for pea-aphid control. These demonstrated that dusts containing 1 percent of parathion, TEPP, or rotenone, or 5 percent of DDT were very effective for the control of this pest under the humid conditions existing in the Central and Eastern States. Equally good results were obtained with sprays containing equivalent strengths of these insecticides. These materials have been widely adopted for use by the growers. Nearly 65,000

acres of peas received treatment with insecticides for pea-aphid control in Wisconsin during 1951.

Investigations in Washington, Oregon, and Idaho on the evaluation of DDT and other new insecticides for pea-aphid and pea-weevil control, in large field plots, resulted in improved methods for controlling these insects when they occurred alone or in association. Sprays and dusts containing 1 percent of parathion were shown to be very effective against both insects. These have largely taken the place of dusts containing 5 percent of DDT or 1 percent of rotenone formerly used for this purpose. Dusts containing 5 percent of methoxychlor—less likely than DDT to leave harmful residues—were shown to be fully as effective against the pea weevil as dusts containing an identical strength of DDT. They cost more than DDT and are relatively ineffective against the pea aphid. In some localities there was an indication during 1951 that the pea weevil may be developing a resistance to DDT. The use of parathion for the control of the pea aphid and the pea weevil has been adopted by the growers on a large scale, a total of approximately 27,500 acres of peas being treated with this material in Washington, Oregon, and Idaho during 1951. In addition, about 7,000 acres of peas were treated with DDT and TEPP.

Insecticide Reduces Spread of Potato Leafroll Disease by Aphids

Field experiments in Washington in cooperation with the Washington State Department of Agriculture and the Washington Agricultural Experiment Station to develop methods of controlling the green peach aphid on potatoes resulted in the development of a dust mixture that gives an almost complete cleanup of the aphids in a few hours and reduces the spread of leafroll disease. This disease damages both the plants and the tubers and is spread by the aphids even when they are too scarce to otherwise cause damage. The dust contains 5 percent of DDT, 0.5 percent of parathion, and 50 percent of sulfur. It is recommended only for potatoes grown in arid or semiarid areas as sulfur may injure potatoes in areas of heavy rainfall. In the experiments in 1951 this dust gave excellent control when applied by aircraft as well as when applied by ground machines. A DDT-parathion emulsion spray applied by aircraft also gave excellent control. The dust has consistently given better results with sulfur in it but evidence was obtained that the sulfur content may be reduced to 12 percent without materially affecting the control of the aphid.

Green Peach Aphid Proves Vector of Foreign Virus Disease

Investigations in Maryland in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering on insect vectors of plant diseases disclosed that an abnormality in the development of greenhouse-grown chrysanthemums recently imported from England and Denmark was identical with tomato aspermy, a disease which had not previously been known to be present in the United States. In experiments with tomato aspermy virus, this disease, which is mechanically transmitted from chrysanthemum to other hosts, was also transmitted by the green peach aphid from tobacco to tobacco or tomato and also from chrysanthemum to tobacco or tomato. The

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aphid is able to infect plants for only about one hour after it leaves the disease-source plant. Tests with other aphids are underway. It is possible that chrysanthemum may serve as a reservoir for this disease from which aphid vectors could carry it to tomato and tobacco where the symptoms are very severe.

Dipping Narcissus Bulbs Controls Bulb Fly

Tests have been continued in Washington and Oregon to develop a practical means of preventing infestation of narcissus bulbs by larvae of the narcissus bulb fly. For application during the late spring period of adult activity naphthalene flakes applied to the soil surface around the growing plants has been the only material which has given a consistently high degree of control against this stage of the insect. Summer-type spray oils, technical benzene hexachloride, and toxaphene, applied to the growing plants, are the most promising of the materials tested so far, but the degree of control obtained from their use has been only fair and attempts to improve control by increasing the number of applications or the dosages have not been successful. However, the method of soaking narcissus bulbs 10 minutes or longer in a solution of aldrin, chlordane, dieldrin, heptachlor, or lindane, prior to planting gave complete protection to the bulbs. No injurious effects were apparent in the bulbs treated with aldrin, chlordane, or heptachlor. Some injury occurred to bulbs soaked in lindane, probably due to the solvent. Stimulation of plant growth of the dieldrin-treated bulbs rendered them susceptible to injury from cold weather. The highly satisfactory results from this method of approach to the problem give the best promise of developing practical recommendations for control of the narcissus bulb fly.

Weevil-Resistant Sweetpotatoes Studied

In investigations on the varietal resistance of sweetpotato plants to the sweetpotato weevil, two sweetpotato seedlings, L187 and L244, developed in cooperation with plant breeders of the Louisiana Agricultural Experiment Station, showed a high degree of resistance to attack of the sweetpotato weevil in experimental-plot tests.

Thrips Infestations in Tomato Fruits Largely a Plant-Breeding Problem

Research work in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Utah Agricultural Experiment Station to develop methods of preventing thrips infestations within tomato fruits was completed and the project is being discontinued. It was shown that thrips infest tomatoes only when the tomatoes, while green, develop open cavities. The thrips feed in the cavities of the green fruits. As the tomatoes grow and ripen the cavities tend to close and trap the thrips, thereby causing the marketed product to be contaminated. Experiments indicated that it is not practical to prevent the ocurrence of thrips within tomatoes by controlling the insect with insecticides. It was also shown that plants that produce tomatoes without cavities can be developed by selection. Thus the problem has become one largely for the plant breeder.

Improved Power-Equipped Crop Dusters Tested

In experiments for the improvement of methods of applying insecticides to vegetables with ground equipment in Oregon and Washington, excellent progress was made in studies of power-equipped ground dusters. Information was obtained on the relation of insect kill to dust-impact velocity, comparative performance of different types of dusters, and dust distribution as affected by an improved boom and semicylindrical aluminum hood designed during the research work. These experiments were conducted principally on peas, with the pea aphid as the test insect, but some preliminary experiments were conducted with this equipment against various insects on cauliflower, clover, and alfalfa. This work was carried on in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, the Agricultural Experiment Stations of Idaho, Washington, and Oregon, the Northwest Canners Association, pea growers, and pea processors.

Insecticidal Dosages for Wireworm Control Compared

In both Washington and California additional information was obtained on the minimum effective dosages of chlordane, toxaphene, aldrin, dieldrin, lindane, and heptachlor for wireworm control and on the effect of these insecticides on truck crops grown in treated soil. Information on whether or not crops grown in soil treated with these materials may constitute a hazard to the consumer must be obtained before any of them can be safely recommended for use in the control of wireworms. Most of these materials were as effective as DDT against irrigated-land wireworms, but did not have any marked advantages over DDT. Methoxychlor, however, proved to be ineffective against wireworms. Heptachlor was particularly effective against the DDT-resistant wireworm *Melanotus longulus* in California. This wireworm has been a relatively minor pest in the lima bean area of California but with the sugar-beet wireworm brought under control with DDT, *M. longulus* is more noticeable and is causing more concern.

As part of the research on the control of wireworms in California, evidence was obtained that excessive dosages of either aldrin, chlordane, or toxaphene in the soil may cause off-flavors in potatoes. Beginning in 1949, plots of Yalo fine sandy loam soil were treated annually with 4 pounds of aldrin per acre, 20 pounds of chlordane, and 20 pounds of toxaphene disked into the top 8 inches of soil. Bliss Triumph potatoes grown in these plots in 1951 were submitted to the Western Regional Research Laboratory of the Bureau of Agricultural and Industrial Chemistry where they were tested for off-flavors by a panel of experienced tasters. The flavors of the potatoes grown in the treated plots were significantly less desirable than those of potatoes grown in untreated check plots. This off-flavor would not necessarily be detected by the average consumer or even the unusually sensitive consumer. Furthermore the dosages of insecticides were higher than would ordinarily be applied to the soil for wireworm control.

Further Studies of Effects of Soil-Applied Insecticides on Tobacco

Experiments were begun in 1947 at Florence, S. C., to determine the effects on tobacco and crops usually rotated with it, of accumulations

of DDT, BHC, and toxaphene in the soil. These experiments are continuing to provide useful information on the disintegration and phytotoxic effects of these materials in the soil. For example, under relatively unfavorable weather conditions, tobacco yields were reduced in 1951 in plots in which 100 pounds of DDT had been mixed with the soil in 1947. Chemical analyses of the soil in these plots in 1951 indicated that only about 40 pounds of the DDT remained. Apparently DDT and toxaphene in the soil decreased at about the same rate. Where 20 pounds of either DDT or toxaphene were applied to the soil each year from 1947 to 1950, inclusive, analyses in 1951 showed only 50 percent of the DDT and 55 percent of the toxaphene remaining. About 90 percent of the BHC was lost in the 4 years. Detailed results during the first 3 years have been published in Technical Bulletin No. 1047.

New Insecticides Tested Against Several Tobacco Insects

In North Carolina, South Carolina, Tennessee, and Florida, TDE was demonstrated to be the most effective of the available insecticides that can be used for the control of hornworms and budworms on tobacco. TDE cannot be recommended without reservations, however, until it is determined more definitely whether or not it will affect the flavor and aroma of the tobacco in the manufactured product. Flavor and aroma tests of tobacco products from plants treated with various formulations of this material in the field in 1951 will be made. Experiments with new insecticides available for experimental work indicated that the stereoisomer of dieldrin is the most effective insecticide ever tested against hornworms and budworms. Considerable work will need to be done before it can be determined whether or not this experimental insecticide can be used on tobacco.

Ways of Utilizing Enemies of Tobacco Aphid Under Study

Studies throughout the South to determine the cause and prevention of outbreaks of the green peach aphid on tobacco indicate that aphid-infested plant beds are the major source of aphid infestation in tobacco fields and that dock and cultivated collard, mustard, and related plants growing nearby are the major sources of aphids in the plant beds. It has been effectively demonstrated in the shade-grown tobacco area of Florida that damage by aphids in tobacco fields can be greatly reduced by eliminating these sources of infestation. Studies on diseases, parasites, and predators of the aphids show that these natural enemies usually keep aphid populations at a low level except during the cooler part of the tobacco-growing season. Additional evidence has been obtained that the most important factor controlling the aphid on tobacco is an unidentified infectious disease which is highly lethal when the maximum temperature is over 90° F. Parasites and predators of the aphid are not effective when the insect is on tobacco. An attempt is being made to determine methods of utilizing these enemies of the aphid to greater advantage and thereby to reduce the need for insecticides.

New Compounds Highly Toxic to Resistant Spider Mites on Roses

Investigations were continued in Maryland on the development of more effective insecticides and methods for their application to control various species of insects and mites infesting roses and other major floral and vegetable crops grown in greenhouses and in the field. Large-scale tests in greenhouses showed that combustible powders containing DMC (Dimite) are highly toxic to resistant spider mites and that three applications at 5-day intervals resulted in practical elimination of these pests on roses. Aramite in sprays or aerosols was shown to be highly effective against resistant spider mites on roses. Aramite sprays in a combination of treatments with schradan or E–1059 aerosols have been tested in commercial greenhouses on roses and have given satisfactory control of resistant spider mites during the summer and fall seasons. In laboratory tests with 26 acaracides the materials were highly toxic to non-resistant spider mites but only Aramite, *p*-chlorophenyl *p*-chlorobenzene sulfonate (Ovotran), DMC, R–242 (Sulphenone) and compound 923 (Genitol) were toxic to resistant strains of these mites.

Systemic Insecticide Breaks Down Rapidly in Plant

Laboratory experiments involving the introduction of measured quantities of schradan into chrysanthemum cuttings, through nutrient solutions, or by foliage applications, followed by subsequent chemical analyses, showed that this systemic insecticide breaks down rapidly in the plant. Tests indicated a difference in the ability of various plants to retain schradan after absorption. Considerable quantities of this material were found in seeds of peas and beans when low dosages were applied to the foliage of the plant but very little schradan was found in the fruits of tomatoes even after excessive applications to the foliage.

Tolerance of Mushrooms to Different Insecticides Tested

Experiments at Beltsville, Md., continued to demonstrate that pyrethrum drenches applied to mushroom beds between flushes or just as the young mushrooms begin to appear above the soil surface do not injure the crop or reduce the yield. Allethrin and methoxychlor also did not cause injury nor did three well-known wetting agents—Santomerse, Triton X–100, and Dreft. In exploratory tests early in 1951 the miticides Aramite, DMC, *p*-chlorophenyl *p*-chlorobenzene sulfonate, and IN–4200 did not cause injury. In tolerance tests with dusts, allethrin, pyrethrum, and lindane did not cause injury. The lindane dusts apparently did not cause any off-flavors in the cooked mushrooms. Lindane emulsion spray, however, caused off-flavors

Practical Control for Pickleworm on Cucumbers and Squash Sought

Work on the control of the pickleworm on cucumbers and squash in South Carolina showed that this insect can be controlled by weekly applications of a 1-percent lindane dust, beginning when the plants

start to form runners and extending through the harvest period. The use of lindane after the first fruits begin to form left a poison residue on the harvested fruits and also resulted in off-flavor in such fruits. Limited experiments with a lindane emulsion spray indicated that in this form lindane was also effective against the pickleworm, but that its use caused the same health and off-flavor hazards as lindane dust. Incidentally it was observed that in both the dust and spray form lindane was effective against cucumber beetles and the melon aphid on cucumbers and squash. Experiments with various insecticides less toxic to warm-blooded animals, including sabadilla, nicotine, rotenone, allethrin, pyrethrum dusts, and a TEPP spray, applied to cucumber plants after the fruits began to form, showed that none of these materials was satisfactorily effective against the pickleworm.

CEREAL AND FORAGE INSECTS

Grasshopper Research and Control

Insecticides protect cotton fields from grasshoppers

Farm-scale tests of the new organic insecticides were made against grasshoppers attacking cotton and other crops on the Bluebonnet Farm, McGregor, Tex. This work was done in cooperation with the Texas Agricultural Experiment Station. Aldrin, dieldrin, and toxaphene sprays were applied to field margins and pastures near or adjacent to cotton fields. Aldrin emulsion at 2.9 ounces an acre practically eliminated all infestations in the early spring. The same results were obtained with emulsions of dieldrin applied at the rate of 1.3 ounces and toxaphene at 1.5 pounds an acre. These tests were conducted when the nymphs were in the third to sixth instars. In later sprayings during July, such dosages did not give control. However, by increasing the per acre dosages of aldrin to 4 to 8 ounces, of dieldrin to 2.8 ounces, and of toxaphene to 3 pounds, results were almost as good as those obtained in the spring. Grasshoppers were all adult when the later sprays were applied.

Grasshopper development synchronizes with abundance of food plants

Studies of the ecology, distribution, and abundance of range grasshoppers confirmed the 1950 findings that the entire range grasshopper complex follows a fairly orderly sequence of hatching, development, and egg laying, synchronized with and dependent upon the development of range grasses, herbs, and shrubs that serve basic food requirements. This sequence of events is apparently maintained year after year, being advanced or retarded within fluctuating limits of the weather. These studies assist in the proper timing of surveys and control operations.

Grasshopper parasites and disease effective in limited areas

Two grasshopper collections in a locality in Montana showed 94 and 97 percent parasitization by nemestrinid parasites. Parasitization in the same locality in 1950 showed a maximum of 80 percent.

In adjacent localities it ranged from 36 to 96 percent. The present abundance of these parasites, their ability to destroy a high proportion of several important range species of grasshoppers and the ease of obtaining their eggs and larvae in large numbers, suggest the possibility of introducing them into range areas where they are now absent or present in small numbers only.

A fungus identified as *Empusa grylli* was a major factor in reducing populations of *Melanoplus bivittatus* in certain sections of Montana. In one section of that State, *Aeropedellus clavatus* was practically wiped out by this fungus.

Grasshoppers killed with new insecticides

Early season tests in Arizona with emulsions of aldrin, dieldrin, heptachlor, compound 1189, and Dilan, applied with a mist blower to alfalfa gave excellent control of grasshopper nymphs. These tests were repeated later in the season on larger plots in Arizona and Montana. Dieldrin at ¾ to 1 ounce and heptachlor at 6 to 8 ounces per acre resulted in 93 to 97 percent mortality in Arizona. Solution sprays were tested on Montana range land—dieldrin at ½ ounce an acre, aldrin at 2 ounces, and heptachlor at 3 to 4 ounces—and they also gave satisfactory kills.

Tests were made to study the residual effectiveness against grasshoppers on alfalfa of spray applications of aldrin, compound 1189, dieldrin, and Dilan. Aldrin lost much of its effectiveness after 28 days but continued to kill up to 49 days. Compound 1189 compared favorably with aldrin but gave no kill after 41 days. Dieldrin was still effective after 62 days. Dilan had no residual effect after 9 days.

All of the insecticides which have proved effective for grasshopper control in the Western States were equally efficient in Florida against the American grasshopper.

New Trends in Grasshopper Control Campaign

Farmers and ranchers step up grasshopper control on crop and range land

States and minor civil divisions have continued their cooperative responsibility for providing technical direction and help in grasshopper survey and control in crop areas. Farmers do the actual control work on their croplands. On privately owned range land increasing numbers of ranchers are finding it profitable to carry on grasshopper control under the same plan as farmers in crop areas. Where grasshopper control on private range is too extensive for individual handling, the problem is currently being met by cooperating States, counties, and individuals providing at least two-thirds of the cost and the Bureau the remainder. Where grasshopper or Mormon cricket infestations on lands owned or controlled by the Federal Government require control, it is the responsibility of the Bureau, as the appropriate operating agency of the Government, to conduct the necessary survey and control operations. In cooperation with the States, surveys of grasshopper adults were made in 1951 in 811 counties in 22 States, and egg surveys in 460 counties.

Much of the control work required during this fiscal year has been on public domain. Federal agencies, including the Forest Service,

Soil Conservation Service, Fish and Wildlife Service, National Park Service, Indian Service, Bureau of Land Management, and Bureau of Reclamation, have contributed some money and have also provided personnel and vehicles. Although a large portion of the cost of control on public domain has been borne by this Bureau, other interested Federal agencies have shown an encouraging trend toward furnishing money, equipment, and personnel.

Control efforts involving ranchers, States, and the Federal Government have been very actively supported by all cooperators. Ranchers have willingly accepted their financial share of each undertaking.

In widespread field operations for the control of grasshoppers and Mormon crickets, the use of Bureau-owned equipment is rapidly decreasing with a corresponding increase in the use of contracted equipment.

Control needs in range land areas exceed expectation

The 1950 fall surveys indicated that grasshopper infestations expected in 1951 would be lighter than they had been in 1950, but that control work would be needed in local crop and range areas to avert damage and reduce populations. Cold, wet weather in many areas during the hatching period caused high nymphal mortality, materially reduced the expected need for control, and, likewise, the infestation that otherwise would have developed in the spring of 1952. The 1951 fall surveys showed that with similar weather conditions the 1952 infestation would be considerably lighter than in 1951. In many areas, however, early spring weather was warm and dry in 1952, infestations developed to their full potential and the amount of control in range land areas materially exceeded expectations.

Range land infestations in the fall of 1951 and spring of 1952 were materially heavier in certain areas in Arizona, California, Colorado, Idaho, Nevada, New Mexico, and Utah, but were lighter in Montana and Wyoming. Cropland infestations in the 24 cooperating Western States were, in general, the lightest for any year since 1943. At the end of the fiscal year population build-ups were apparent over wide areas in the Western States, indicating probable need for increased control in 1953.

Cooperative control of grasshoppers on range land during the fiscal year involved the treatment of 572,500 acres in eight States—18,300 acres in Arizona, 40,000 in California, 2,600 in Idaho, 17,600 in Montana, 5,600 in Oregon, 45,200 in Utah, 2,600 in Washington, and 440,600 in Wyoming.

The spray work in Arizona, Idaho, Oregon, and Washington was done with Bureau-owned aircraft. Contract planes were employed in California and Wyoming. Both Bureau-owned and contract planes were used in Montana. In addition to aircraft, a limited amount of ground equipment was used to do control work in California and Utah.

Aldrin was the insecticide used most widely in grasshopper control in both cropland and range land areas. Confidence in its effectiveness was further increased by its long residual action and by its performance in effecting near eradication of all species of grasshoppers against which it was used.

The relative proportion of crop acres sprayed, as compared to acres baited, increased still further in 1951.

Mormon Crickets Important Only in Nevada and Utah

The Mormon cricket survey in 1951 revealed a light infestation of the insects in Moffat County, Colo.; a light infestation in Clark County, Idaho; a moderate infestation in Chouteau County, Mont.; 20 separate infestations, varying from light to severe, on approximately 200,000 acres in Elko, Humboldt, Pershing, Lander, and Eureka Counties, Nev.; infestations in Daggett, Tooele, and Uintah Counties, Utah, embracing 7,500 acres heavily infested, 13,500 acres moderately infested, and 17,000 acres lightly infested; very light infestations on 6,000 acres in Morrow and Umatilla Counties, Oreg.; and very light infestations on 12,000 acres in Franklin and Adams Counties, Wash. A presumed light infestation of crickets on contiguous range areas of Daggett County, Utah, and Sweetwater County, Wyo., was expected to involve some 4,000 acres in Wyoming. By baiting 1,500 acres as crickets banded, this infestation was controlled.

Surveys disclosed that although there were many reports of Mormon crickets being seen in old outbreak areas in several States, there would be no important increase during 1952 except in Nevada and Utah. Findings in Nevada indicated that several rather extensive infested areas had not been found in the 1951 survey and pointed to the necessity for aggressive, wide-scale control operations in 1952 if another major outbreak of the species was to be averted in that State.

In Utah 39,000 acres were found infested. This was a considerable extension of previously known infestations there, indicating the probability that another heavy infestation was developing.

The Nevada outbreak in 1952 proved to be much greater than anticipated from the 1951 survey, requiring more extensive control operations than had been anticipated.

Chlordane or toxaphene oil-impregnated bait was applied by airplane and ground equipment to 123,400 acres of infested range. Results were excellent. Areas that could not be baited now harbor populations sufficient to create an outbreak in 1953—one that may be much more severe and extensive than that fought in 1952. Contiguous to the western Nevada infestation were those in Lassen and Plumas Counties, Calif., where an additional 4,500 acres were baited for Mormon cricket control.

In Daggett, Sanpete, Tooele, Juab, and Uintah Counties, Utah, 87,600 acres of range and crop land were baited or sprayed for Mormon cricket control in 1952. Excellent control was obtained. Both ground and air equipment were used. Bait or spray applications by farmers in Sanpete County were made to growing crops. Aldrin at the rate of 3 ounces per acre, applied as spray, prevented any crop injury and averted the danger of an outbreak in 1953.

Mormon Cricket Build-Up Indicated

Infestations of Mormon crickets in Oregon and Washington were the lowest since 1937. Although there were no important infestations reported in Idaho, infestation is building up there. The Moffat County, Colo., infestation, including the historically important Zenobia Basin, is also increasing. There are other indications that build-ups are starting in California, Nevada, and Utah.

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Chinch Bugs

Chinch bugs going into hibernation in the fall of 1951 were too few in number to indicate any need for advance preparations for their control. Later observations confirmed that no control was necessary in any of the Central and Midwestern States in 1952.

European Corn Borer Research

Low level of European corn borer infestation in 1951

Fall surveys by agricultural agencies in 33 States indicated the distribution and abundance of the corn borer in 1951. The insect was found in 51 counties not previously known to be infested and was reported for the first time from Montana. The area in the United States now known to be infested includes 1,456 counties in 37 States. Over the infested area as a whole, the European corn borer remained at a low level of infestation. It was less abundant in 1951 than in 1950. Although the general average population in the North Central States in 1951 was lower than in 1950, the insect was more numerous in parts of eastern South Dakota and southwestern Iowa. The insect showed some increase in the Eastern States, especially in Delaware, Maryland, and New Jersey, and the surveyed parts of Pennsylvania and Virginia. It is estimated that 35,812,000 bushels of grain corn, valued at $57 million, were destroyed by the European corn borer in 1951.

Progress in testing of borer-resistant corn strains

Thousands of strains of field corn, sweet corn, and popcorn were tested during the year for resistance to the European corn borer. The work was performed in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and various State agricultural experiment stations. A number of inbred lines have now been identified as resistant or tolerant to the borer. Among the important newer lines of dent corn having a good level of resistance are Oh43, Oh45, Oh41, Oh5, Oh4c, W22, W112, N1, N32, A295, A277, and B7. Hybrids K62, W64, W44, C54, C47, and L41, released by the Ohio Agricultural Experiment Station and designated as resistant to the European corn borer, contain the resistant or medium-resistant inbreds Oh43, Oh45, Oh41, Oh51A, and Hy.

European corn borer kill obtained in laboratory with new insecticides

In cooperative investigations with the Iowa Agricultural Experiment Station, 158 new insecticide compounds were tested against newly hatched corn borer larvae in the laboratory. Of these, endrin (Compound 269) and isodrin (Compound 711) were the most toxic to the insect. Twenty compounds found promising in this and previous laboratory screening were tested in small plots in the field. Under the low number of borers prevailing in these tests in 1951, four of these compounds, endrin, isodrin, EPN, and heptachlor, gave outstanding kill. Seven other insecticides were as effective as DDT, the most widely used insecticide recommended for corn borer control at the present time. In addition, EPN, one of the promising materials in the small-plot tests, was equal to DDT in the field-scale tests.

Better Sweet Corn Due to Research

New sweet corn hybrids resist corn earworm attack

New sweet corn hybrids coming on the market in the last 3 or 4 years have about half as much earworm injury as did Golden Cross Bantam or Ioana when work began to test the resistance of sweet corn to the corn earworm. Use of these hybrids has resulted in a reduction of 40 to 50 percent in the amount of loss to sweet corn from this pest during the last few years. The Evergreen hybrid 471–U6 x 81–1 was released by the Purdue Agricultural Experiment Station in 1952 and the still more resistant Evergreen hybrid Illinois 14n x 81–1 will probably be ready for release in a year or two. This breeding work was done in cooperation with plant breeders in the Bureau of Plant Industry, Soils, and Agricultural Engineering and the States of Illinois, Indiana, Iowa, Mississippi, Ohio, South Carolina, and Texas.

Several insecticides satisfactory for corn earworm control

More than 300 tests were carried out in four States to develop better insecticidal control methods for the earworm in market and canning sweet corn and in seed corn. DDT and heptachlor gave consistently good results. TDE, Dilan, Prolan, Bulan, endrin, and toxaphene were outstanding in one or more tests, indicating that they too may be satisfactory provided better formulations or methods of using them are devised. Analyses show that where corn was sprayed with DDT emulsions, the residue of DDT on kernels at harvest was negligible.

Wheats and Barleys Resistant to Hessian Fly

Ponca, a new wheat variety released by the Kansas and Oklahoma Agricultural Experiment Stations in 1951, possesses the highest level of hessian fly resistance now available in a commercial variety of hard red winter wheat. It is also highly resistant to leaf rust. Three promising new fly- and leaf-rust-resistant strains of soft wheat were tested in field plots in Indiana. They are superior in yield to the best of the present commercial varieties, and the release of at least one of them is anticipated by the fall of 1954.

Testing of 200 barley varieties for their resistance to hessian fly showed that 8 of them could be tentatively rated as resistant. The outlook for producing fly-resistant barleys is very good, as the resistance is controlled by one or two genes in the parents.

These tests were made in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the States of Georgia, Indiana, Kansas, Missouri, and Pennsylvania.

Progress in Wheat Stem Sawfly Investigations

According to a survey in 1951 the wheat stem sawfly infested wheat in all of Montana east of the Rocky Mountains, all of North Dakota, most of northwest South Dakota, and much of northeastern Wyoming. The heaviest concentrations were in northern Montana east of the Rocky Mountains, and in northwestern North Dakota. The sawfly is present in native grasses in southern South Dakota but does not migrate to wheat fields. Apparently, wheat in this area ripens too early for the sawfly larvae to mature and overwinter successfully. Wheat

losses in 1951 were estimated to amount to 1,400,000 bushels for Montana and 3,500,000 bushels for North Dakota. Total sawfly losses for both States were estimated at $10 million, based on the average prevailing wheat prices at harvesttime.

Dieldrin, aldrin, heptachlor, parathion and allethrin were tested as systemics to destroy the feeding larvae in the wheat stems. In addition experimental soil applications of Systox, octamethyl pyrophosphoramide, heptachlor, dieldrin, and aldrin were made at three different times during the growing season. None of these materials gave effective control although Systox destroyed 38 percent of the larvae in the stems when applied after the peak of adult emergence. Chemical treatment of seed wheat prior to planting was not encouraging.

The most satisfactory cultural method for controlling the wheat stem sawfly consists of a shallow cultivation with a one-way disc plow in the fall, followed by deep plowing with a moldboard plow in the spring. This treatment reduced the number of adults emerging from the overwintering larvae by 63 percent.

In the winter-wheat plots at Choteau, Mont., 2,557 foreign and domestic winter wheat varieties were screened to determine their resistance to the sawfly. All were found susceptible and discarded. Solid-stem wheats are being emphasized in the winter wheat plantings, as they appear to be the only immediate source of sawfly resistance. The resistance work was done in cooperation with plant breeders in the Bureau of Plant Industry, Soils, and Agricultural Engineering.

The wheat stem sawfly investigations were conducted in cooperation with the Montana and North Dakota Agricultural Experiment Stations.

Promising Research on Sugarcane Insects

Sugarcane borer infestation light in Louisiana and Florida

In the sugarcane section of Louisiana, the winter of 1950–51 was the coldest since 1899. This resulted in the lightest spring borer infestation on record and one of the lightest at harvesttime. A 1951 survey of sugarcane at harvesttime in Louisiana showed an average of 4.8 percent of the cane joints bored as compared with 17.2 percent for the same areas in 1950. Numbers of aphids and other sugarcane insects were also the lowest on record. According to a similar survey in Florida, from 2.8 to 8.4 percent of the joints were bored, a lower figure than in 1950.

Sugarcane tested for borer resistance

Seven commercial and two unreleased varieties of sugarcane were examined for sugarcane borer infestation at Houma, La. Three of these carried more resistance than the resistant variety C. P. 34/120. In Florida the replacement of susceptible with resistant varieties has been of great value in decreasing borer injury. The resistant varieties in that State also produced the highest yields of sugarcane per acre. This work was conducted in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Florida and Louisiana Agricultural Experiment Stations.

Controls sought for various sugarcane insects

Soil samples taken from small plot experiments in Louisiana showed 64 percent fewer injurious soil insects in plots treated with

1-percent toxaphene or 1-percent chlordane at the rate of 400 and 200 pounds an acre, respectively, than in untreated plots. At the same time there was a 14 to 31 percent increase in stand in the treated over the check plots. The most destructive insects were wireworms and the lesser cornstalk borer. In Florida tests, wireworms were best controlled with 2 pounds of parathion, 3 pounds of aldrin, 2 pounds of the gamma isomer of BHC, or 6 pounds of chlordane an acre.

Improved Control Methods for Injurious Legume Insects

Excellent control of heavy populations of the potato leafhopper on alfalfa was obtained in Maryland and Ohio in several tests with methoxychlor at dosages ranging from 0.3 to 0.8 pound applied in 5 gallons of water emulsion spray an acre. A dosage of 0.5 pound an acre applied about 3 weeks before harvest is being recommended to the grower.

Tests in Utah with water emulsion sprays applied with a low-pressure field sprayer to alfalfa in the bud stage indicated for the third year that toxaphene at 3 pounds or dieldrin at 0.25 pound per acre gives good control of lygus bug nymphs for a 3-week period. Both of these insecticides were as effective as the now recommended DDT at 1½ to 2 pounds an acre. Aldrin at 0.5 pound an acre furnished good control for 2 weeks in preliminary trials. Endrin and isodrin applied at 0.2 pound an acre and heptachlor at 0.25 pound an acre gave control of lygus bug nymphs similar to that obtained with DDT.

A dieldrin water emulsion spray applied to alfalfa 1 to 2 inches high in the early spring at the rate of 0.25 pound of dieldrin per acre effectively controlled alfalfa weevil adults before they could lay eggs. Dieldrin is now being recommended along with chlordane for early spring treatment of both seed and hay alfalfa. In recent experiments the most promising insecticides against the larvae of the alfalfa weevil were aldrin at 2 ounces and heptachlor at 2½ ounces an acre.

Emulsion sprays containing 0.75 to 1 pound of methoxychlor an acre gave good control of spittlebug nymphs in Maryland on alfalfa and red clover. The application of benzene hexachloride containing 0.25 pound of gamma isomer per acre gave excellent control of the spittlebug on red clover in Ohio.

Under Utah conditions DDT applied for lygus bug control on alfalfa is usually effective against the pea aphid on the same crop. When additional sprays were needed, 1 pint of 25-percent emulsifiable concentrate of parathion or 1 pint of 40-percent TEPP in 6 to 8 gallons of water an acre gave good control.

Plot treatments in the fall with aldrin or chlordane as dilute dusts in Ohio effectively reduced infestation of the clover root borer, as determined by an examination of the roots in the following August.

Extensive tests in southeastern Virginia, carried out in cooperation with the Virginia Agricultural Experiment Station, showed that 2 pounds of aldrin or 25 pounds of toxaphene an acre applied immediately prior to the first cultivation was effective in controlling the southern corn rootworm on peanuts. Neither insecticide when so applied caused off-flavor in the peanuts or in peanut butter prepared from the treated peanuts. Preliminary tests with dieldrin and heptachlor gave promising results.

The clover seed weevil *Miccotrogus picirostris* was found for the first time in Ohio on alsike clover, in Indiana on red clover, and in southeastern Idaho on white clover. A snout beetle, *Sitona lineata*, known as a pest of vetch, peas, and young seedlings of clover and alfalfa, was found for the first time in Oregon.

The legume insect investigations were conducted in cooperation with agricultural agencies in California, Maryland, Ohio, Oregon, and Utah.

Studies of Insects Attacking Small Grain Crops Intensified

Investigations of insects attacking small grains were expanded during the year. Three additional stations were established—at Garden City and Manhattan, Kans., and Denton, Tex. One entomologist was placed at each of these stations. Another entomologist was added to the already established station at Stillwater, Okla. These studies were conducted in cooperation with the agricultural experiment stations of Kansas, Oklahoma, and Texas and with the Bureau of Plant Industry, Soils, and Agricultural Engineering.

Forty-one varieties of wheat, including all of the adapted commercially grown varieties, were tested for resistance to greenbugs in the wheat nurseries operated in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering and the Oklahoma Agricultural Experiment Station. The most resistant varieties were the wheats Seabreeze and Denton, and a rye x wheat hybrid. The oats variety Tennex was the most resistant of any of the 36 varieties of oats tested. The reaction of 50 barley varieties to a heavy infestation of greenbugs under field conditions was tested. Of these, Omugi, unnamed C. I. 5096, Tongpori, Dobaku, and Zairai were the most resistant.

In preliminary tests good protection from greenbugs was obtained for as long as 6 weeks when barley and oat seeds were treated with Systox in activated charcoal. Malathon in early tests appeared to be as effective for greenbug control as the now recommended parathion, although a higher acre-dosage of the material was necessary.

Wheat jointworm infestation was heavy in sections of Maryland, Virginia, New York, Illinois, and Missouri. Some wheat x Agropyron strains and 1 wheat variety introduced from France showed low infestations or freedom from infestations in nursery tests at Kearneysville, W. Va., and Columbia, Mo. Plant breeders of the Bureau of Plant Industry, Soils, and Agricultural Engineering and the States of Indiana, Illinois, and Missouri cooperated in these tests.

STORED-PRODUCT INSECTS

Fumigation and Dusting Control Grain-Infesting Insects

Experimental work on the fumigation of shelled corn stored in steel bins in Indiana demonstrated that by the addition of 10 percent by volume of methyl bromide to a 3 : 1 mixture of ethylene dichloride and carbon tetrachloride or an 80–20 mixture of carbon tetrachloride and carbon disulfide, the dosage required to give a completely satisfactory kill of all stages of grain-infesting insects could be reduced to 2 gallons of either mixture per 1,000 bushels of corn.

A protective dust containing 1.1 percent piperonyl butoxide and 0.08 percent pyrethrins, when added to newly harvested wheat in Kansas at the rate of 75 pounds per 1,000 bushels, provided effective protection against insect infestation for a 3-month period following harvest.

Weekly Spraying Reduces Tobacco Storage Losses

A study was made of actual loss of flue-cured leaf tobacco in storage. No appreciable damage was found in tobacco in storage one year or less. Tobacco in storage 2 years or more did show appreciable loss. Where no insect control was practiced this loss was found to amount to nearly 2½ pounds of tobacco per hogshead. Weekly spraying with pyrethrum-oil reduced this loss appreciably, the reduction ranging from 27 to 37 percent.

A comparison was made in tobacco warehouses of the relative effectiveness of pyrethrum-oil space spray, of HCN fumigation, and of fumigation followed by weekly spraying. Against the tobacco moth it was again demonstrated that weekly applications of pyrethrum-oil space spray gave almost perfect control, appreciably better control than warehouse fumigation. Against the cigarette beetle, in a very light infestation, pyrethrum-oil spray gave satisfactory control. In a moderate infestation of the beetle, warehouse fumigation with HCN followed by weekly spraying was fairly effective, as was also a single warehouse fumigation. In a heavy infestation, two fumigations failed to give satisfactory control. In a large-scale experiment 8 tobacco warehouses were sprayed weekly with 2½ percent of lindane in oil. Control of the tobacco moth was excellent but control of the cigarette beetle was unsatisfactory. No difficulty was experienced in handling or applying this insecticide.

Insecticides Show No Repellency to Tobacco Insects

Studies were made on the repellent action of two insecticides to tobacco insects. In one experiment on the repellency of paper hogshead liners impregnated with pyrethrum-piperonyl butoxide, no repellency was noted after one year in storage. In an additional experiment, cases and hogsheads of tobacco were sprayed with lindane sprays containing up to 2 percent of lindane. Spray was applied to the exterior and interior of the cases and hogsheads. Sprayed hogsheads were as readily infested by the cigarette beetle and the tobacco moth as unsprayed ones.

DDT-Plastic Treatment Protects Animal Hair Padding

Horsehair treated with DDT in a plastic coating remains undamaged after 18 months. Allyl starch and rubber cement appear to be promising adhesives for DDT on animal hair used for insulation or padding.

Low Concentrations of Insecticides Protect Fabrics

The lowest concentrations of DDT, dieldrin or lindane which gave complete protection from insect damage to cloth in laboratory tests were determined as 0.05, 0.1, and 1 percent respectively. The 0.5-

and 1-percent dieldrin and 1-percent DDT treatments gave protection to the cloth after three washings. None of the treatments withstood dry cleaning.

Comparative Toxicity of Three Insecticides to Black Carpet Beetle Determined

In comparative toxicity studies using lindane, chlordane, and DDT dusts, against black carpet beetle larvae, lindane at 12.5 mg. per square foot was faster acting and produced higher mortalities than chlordane at 30 mg. or DDT at 50 mg. Chlordane acted considerably faster than DDT.

Commercial Mothproofing Sprays Effective

Studies of three low-pressure gas-propelled mothproofing sprays revealed that when they were used as directed by the manufacturer, no deposit was visible on the cloth either during or 48 hours after treatment. A 7-day exposure of black carpet beetle larvae on the treated cloth showed that the treatments were effective in preventing insect damage.

Treated Rug Still Protected After Eighteen Months' Use

Biological tests showed that a rug treated with 0.5 percent DDT by weight was still protected against damage by fabric insects after being subjected to constant walking and weekly vacuum cleaning for 18 months. By chemical analysis, it was determined that walking and vacuum cleaning for 18 months had reduced the DDT residue from 0.41 to 0.17 percent by weight.

Treatments for Quarantined Plants Tested

Seedling tomato plants grown in DDT-treated soil 29 months after application were retarded in growth. At transplanting time, plants in soil originally treated at rates of 10, 25, and 50 pounds of DDT per acre were reduced in height by 0, 27, and 28 percent, respectively, and in weight 22, 40, and 53 percent. Previous experience had shown that such retarded plants regain normal condition when transplanted into untreated soil.

Very unsatisfactory distribution of methyl bromide resulted when the load was placed directly on the floor in a 65-foot vacuum chamber. Forced circulation with a blower did not correct the poor distribution until the load was placed on floor racks to permit circulation beneath the load.

Added experimental work permitted the hot water treatment for lily-of-the-valley pips contaminated with golden nematode cysts to be lowered from 30 minutes at 120° to the same time at 118° F. An attempt to treat the pips in Germany before freezing and storage was not successful. This procedure caused a serious deterioration of the pips.

A fumigation dosage schedule of ethylene dibromide for the treatment of Puerto Rican mangoes was developed and recommended. The method was approved for use October 1, 1951.

Continued germination tests with tree seeds have failed to show any effect from methyl bromide fumigations at normal rates of application.

Insect Repellent Glues Protect Sealed Cartons

Fibreboard cartons sealed with insect repellent glues containing pyrethrins plus piperonyl butoxide showed effective resistance to insect penetration for 14 months. Other tests of fibreboard cartons of dry foods, prepared by commercial concerns, showed that of those tested wet wrap packages were most resistant to insect penetration.

Infested Shelled Corn Successfully Treated With Insecticidal Aerosol

In a preliminary test of the application of an insecticidal aerosol to a mass of 40,000 bushels of shelled corn stored in a Quonset building, unexpectedly good results were obtained. The aerosol was drawn through the load by a ventilating system installed to dry the corn.

Corn Sprayed for Corn Ear Worm Shows Less Rice Weevil

A study of the effect of corn ear worm infestation on field infestation by the rice weevil showed that reduction of corn ear worm populations resulted in lowered field infestation by the rice weevil. In unsprayed corn, 89 percent of the ears were infested by corn ear worm, 96 percent by the rice weevil with an average of 8.2 weevils per ear. In corn sprayed with 5 percent DDT, 46 percent of the ears were damaged by the ear worm, 67 percent were infested by weevils with an average weevil population of 1.8 weevils per ear.

The rice weevil infestation in a field of corn that was isolated from a source of infestation by crib sanitation practices was very low, while fields on farms which did not practice crib cleanup were heavily infested.

Fumigants Applied by Remote Control

Large quantities of fumigant mixture were successfully applied to shelled corn stored in Quonsets without the operator having to enter the building. By means of a spray boom drawn over the surface of the corn on a wooden sled the fumigant was uniformly applied over the surface of the corn. This method is of especial value in applying fumigants containing methyl bromide.

Cowpeas Fumigated Under Tarpaulins for Weevil Control

In tests with a mixture of 15 percent of ethylene dibromide and 85 percent of carbon tetrachloride, complete kills of all stages of weevils were obtained in the fumigation of cowpeas under tarpaulins.

Fumigants May Affect Germination in High-Moisture-Content Cowpeas and Beans

The effect of several fumigants on the germination of blackeye cowpeas and common beans of several levels of moisture content was determined. The fumigants tested included methyl bromide, chloropicrin, ethylene dibromide mixtures, and hydrogen cyanide. Each variety was divided into samples containing 10, 12, 14, and 16 percent moisture. Results of the tests indicated that greater injury resulted in seeds that had moisture contents of 14 and 16 percent than in those

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containing 10 and 12 percent. Of the fumigants tried, HCN, and ethylene dibromide mixtures were the least injurious. In instances in which germination was affected the blackeye cowpeas appeared to be the most susceptible and the small whites the most resistant.

FOREST INSECTS

Characters Symptomatic of Tree Susceptibility to Pine Beetle Attack Determined

It has been known for years that certain ponderosa pines, showing symptoms of weakness and decline, were more susceptible to attack by the western pine beetle than more vigorous fast-growing trees. In an effort to determine tree characters that are indicative of high risk to attack, studies have been under way for some time to so classify these characters that they may be used in removing susceptible trees from stands through sanitation-salvage logging. Results have now been obtained from nearly 8,000 trees that were classified and tagged 10 years ago. These trees occurred in 30 separate 10-acre plots in eastern Oregon. It was found that five characters, as follows, were the most symptomatic of tree susceptibility to pine beetles: (*a*) Fading or off color needles; (*b*) active spike tops; (*c*) very thin, open crowns; (*d*) dying terminal twigs and branches; and (*e*) short needles with small needle complements.

Benzene Hexachloride Controls Turpentine Beetle on Pines

Since 1949 the black turpentine beetle has been killing pines all the way across the South from the Atlantic into Texas. Prior to 1949 this insect was considered of secondary importance since it was not known to be an outright killer. It is having a serious effect on the naval stores industry; also, a number of owners of small plots have clear-cut their timber rather than contend with the beetle. Research this year has been directed toward determining provisional methods of control. Benzene hexachloride dusts, water suspensions, and oil solutions have been found effective in tests and on an operational scale in controlling the beetle. The suspensions and oil solutions also were found effective in preventing and controlling active infestations in standing trees.

Selective Tree Removal Reduces Damage by Western Pine Beetle

The effort to develop an effective method of controlling the western pine beetle by removing and utilizing trees that are most likely to be attacked by this insect has been very successful in certain of the interior-type ponderosa pine stands of the Western States. Losses have been materially reduced where these practices have been employed and more and more of the timber-owning and -managing agencies in the region are modifying their cutting operations to include the principles of high-risk cuttings for the purpose of western pine beetle control.

Bark Beetles Controlled at Lower Costs

In studies designed to improve methods for controlling bark beetles with insecticides, tests were conducted in northern Idaho to compare the effectiveness of ethylene dibromide-oil solutions and emulsions,

and orthodichlorobenzene in oil. Western white pines and lodgepole pines infested with mountain pine beetles were used. Preliminary results indicate that all of these formulations were equally effective in controlling mountain pine beetles in these trees. For control of the Black Hills beetles in ponderosa pine, ethylene dibromide emulsions continue to prove effective. These results, in keeping with those previously reported for the Engelmann spruce beetle, indicate a widespread gain in the reduction of direct control costs of several of our most important bark beetle pests.

New Device Improves Spray Distribution From Helicopter

An apparatus has been developed for use on a helicopter to improve spray distribution and to deposit heavier dosages of DDT insecticides from the air. This device utilizes air from the engine cooling fan and from the exhaust stacks to assist in breaking up the spray as it leaves the helicopter. It, therefore, produces finer atomization of spray at slow speeds than the nozzle-boom-type of spraying apparatus that has been used heretofore on helicopters. In comparative tests with airplanes and helicopters to determine their relative effectiveness in applying sprays to control the gypsy moth it was found that both machines provided complete control with dosages of 1 pound of DDT per acre. In these tests, however, the helicopters deposited twice the amount of DDT deposited by the airplane from a given amount of spray. In contrast with effective control of the gypsy moth it was found that the European pine shoot moth infestations were not satisfactorily controlled when as much as 4 pounds of DDT in 4 gallons of oil were applied to red pines. The State of Connecticut cooperated in some of these studies.

Sprays Tested for Control of Several Destructive Forest Insects

Several insecticidal formulations were tested in unsuccessful attempts to control *Matsucoccus* scales on red pine. On the other hand, applications of Aramite, Dimite, and Oratran with mist blowers gave good control of spider mites when used at dosages of 5 to 8 gallons per acre. By applying lead arsenate to the leaders of white pine remarkable control of the white pine weevil was obtained, with only 8 infested trees showing up among 21,000 that were treated. The State of Connecticut cooperated in these studies also.

Means of Recognizing Incipient Infestations of Spittlebugs Found

Improved methods were sought for surveying Saratoga spittlebug infestation, and for evaluating the use of DDT sprays for controlling it in plantations. These studies were conducted in cooperation with the United States Forest Service on national forests in Wisconsin and Michigan. It was observed that spittlebug feeding causes a reduction in shoot growth, and that this can be detected by growth measurements. The practical value of this development lies in the use it may have in providing a method for recognizing outbreaks in their early stages, thereby permitting the application of control measures before trees are seriously damaged. Studies on DDT-sprayed plantations show that no recurrence of spittlebug attack occurred for periods of 3 to 4 years after spraying.

Oleoresin-Content May Affect Pine Resistance to Insect Attack

In cooperation with the Institute of Forest Genetics, United States Forest Service, studies were made to determine the relative resistance of a Jeffrey-ponderosa pine hybrid to the three most important species of bark beetles in California. Preliminary results reveal that the hybrid is resistant to western pine beetle attack, but not to attack by the mountain pine beetle and the Jeffrey pine beetle, and that resistance or susceptibility of a tree to insect attack is determined by the kind of oleoresins it produces.

Several Treatments Effective in Protecting Wood Products From Attack by Powder Post Beetles

Several of the new residual insecticides were tested for effectiveness in preventing powder-post beetles of various kinds from attacking structural timbers, flooring, furniture, and other wood products. The value of methyl bromide as a fumigant in controlling infestations of these beetles in timber was also determined. Results show that by treating wood with benzene hexachloride, chlordane, or DDT, attack by one of the most injurious of these beetles has been prevented for 3½ years. Methyl bromide has been found to completely control *Lyctus* infestations in handles and the large powder-post beetle, *Hylotrupes*, in the center of 8-inch timbers when applied at rates of 1, 3, and 9 pounds per 1,000 cubic feet of space for periods of 24, 12, and 6 hours, respectively.

New Developments in Preventing Termite Attack

Studies were continued to determine the most effective and economical soil poisons for use in preventing termite entry into buildings; also to determine the toxic effects of various soil poisons on plants that grow around buildings in order to recommend how and when these poisons should or should not be used. Results show that in addition to DDT and sodium arsenite, benzene hexachloride is also an effective soil poison and that chlordane, dieldrin, and aldrin offer promise in preventing entrance to buildings. In Mississippi, for example, benzene hexachloride has prevented termite entry for 5 years in tests conducted cooperatively with the Department of Defense, Corps of Engineers. Research on the toxicity of soil poisons to plants is incomplete, but indications are that formulations of chemicals will be developed which may be used in the soil around buildings with little hazard to plants.

In Mississippi, studies were made in cooperation with the Department of the Army to evaluate available chemicals and test new insecticides in an effort to determine their effectiveness, when applied to the surface of wood, in preventing termite attack. As a result of these studies it has been found that pentachlorophenol, widely recommended for surface treatment, has given mediocre protection against termites. On the other hand, copper naphthenate, never before fully tested, is proving effective in preventing termite attack and decay. Finally, an important finding has been the good protection provided against termites and decay by benzene hexachloride and DDT in combination with a good fungicide, when applied to the sur-

face of wood in a 3-minute dip. This latter combination continued to furnish protection after two years' exposure of the treated wood to direct contact with the soil.

Organic residual insecticides such as benzene hexachloride, chlordane, and DDT have been found effective in controlling active infestations of drywood termites and in preventing subsequent attack. When applied to the surface of wood containing infestations near the surface they have given excellent control. When injected under low pressure into wood containing deep-seated infestations they have also given excellent control. When these materials are dissolved in liquids capable of penetrating wood to a slight degree they have been found to enter and follow termite galleries where they are eventually deposited in the form of crystals. These may kill by direct contact or by fumigation. This is especially true with benzene hexachloride.

Natural Parasites Survive DDT Spraying for Spruce Budworm Control

The effect on natural factors of control—particularly parasites—of aerial sprays applied in Oregon to control the spruce budworm was determined. Observations during 1951 in areas sprayed in 1949 and 1950 showed that most parasites were present in these areas; furthermore that the percentage of parasitization of overwintering budworm larvae was actually higher in the sprayed than the unsprayed areas. The studies strongly indicate, therefore, that airplane spraying with DDT did not eliminate budworm parasites in the treated areas.

Better Methods of Aerial Detection of Forest Insect Infestations Developed

More accurate, rapid and economical methods of detecting and appraising forest insect infestations in the eastern United States by aerial surveys were developed in work performed in Maine in cooperation with the State. One phase of the study consisted of using a line-strip survey method and recording on a moving chart the extent of spruce budworm defoliation of balsam fir. Approximately 0.7 percent of the entire area of some 10 million acres was surveyed in 23.7 hours of actual flying time. The flight crew consisted of a pilot and two observers. The cost of the operation was only $0.18 per 1,000 acres. It was shown, therefore, that spruce budworm infested forests could be surveyed faster, more intensively, and more economically from the air than from the ground. A second phase of the study consisted of testing the value of stereo color photographs in appraising white pine weevil damage in plantations, especially in the taller stands of pines where height and density of crowns interfered with observations from the ground. An analysis of results showed that infested trees could be photographed from the air with a satisfactory degree of accuracy.

Higher Altitudes Specified for Aerial Spraying for Spruce Budworm Control

Tests were made to determine the feasibility of decreasing the hazard of low flight over forests in airplane-spraying operations by increasing the altitudes of flights. Tests were made of spray distribu-

tion and deposit when planes were flown both upwind and crosswind over open ground at altitudes of 50 and 200 feet. It was shown that spray was distributed over a much wider swath when liberated at 200 feet, although there was no difference in the total volume of spray that reached the ground from the two heights. This indicates that in spraying large areas it is feasible to fly higher than previously recommended. As a result of these findings, it has been incorporated in bid specifications that airplanes be allowed to fly at heights of 100 to 250 feet in the spruce budworm control program to be conducted in Oregon and Washington in 1952. Prior to these tests heights recommended were from 75 to 250 feet.

Fifth Instar Spruce Budworm Larvae Most Vulnerable

An airplane-spraying experiment was conducted in Quebec, Canada, in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering, State of Maine Forest Service, and the Quebec Department of Lands and Forests, to determine the proper timing of spray applications and the optimum degree of atomization and minimum dosage of DDT sprays for spruce budworm control. Results indicated that the spray should be applied when the majority of budworm larvae are in the fifth instar, at which time new balsam fir foliage is an inch or more in length; that the spray should be atomized until the average spray droplet is medium in size (mass median diameter, 150 microns); and that the minimum dosage for control is 1 pound of DDT in 1 gallon of spray solution per acre.

Gypsy Moth Control Campaign Progresses

Extensive acreages sprayed to control gypsy moth

More than 217,000 acres of gypsy moth infested area were sprayed with DDT during the spring of 1952 through the cooperative efforts of the Bureau and State agencies. About 15,000 acres were sprayed with ground equipment. The remainder was treated by airplane. Two federally owned C–47 aircraft sprayed approximately 110,000 acres, State-owned biplanes 20,000 acres, and commercial contractors' planes 71,000 acres.

It is believed that the spraying of slightly more than 21,000 acres in or near Ransom Township, Lackawanna County, Pa., has eradicated the gypsy moth infestation there. Spraying of 13,000 acres of infested woodland in northwestern Connecticut and 32,000 acres in western Vermont, mostly in territory near Lake Champlain, has prevented damage to forest growth by the gypsy moth in treated areas and will minimize the hazard of wind spread of small larvae into adjacent territory in New York State. Spraying of 150,000 acres in New York included all known spots of gypsy moth infestation west of the Hudson River and in the northern Champlain Valley. Areas accessible to mist blowers in the generally infested area east of the Hudson River were also covered.

Bait-lure material collected in Portugal

A successful pupae-collection program was again carried on in Portugal in the spring of 1952. Approximately 564,000 female gypsy moth pupae were collected. From these, nearly 350,000 abdominal tips of issuing moths were obtained for use in preparing lure material for future trapping programs.

Substantial increase in gypsy moth infestation found

During the winter of 1951–52, some 500,000 acres were scouted for the gypsy moth in Connecticut, Massachusetts, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. A total of 954 infestations comprising more than 39 million egg clusters were found as a result of this work. A substantial increase in gypsy moth numbers was noted throughout the generally infested parts of New England. Extensive areas of partial to complete defoliation had been located at the end of the fiscal year at various points in New England. Final defoliation figures for the 1952 season may reach a total of 300,000 acres.

Further simplifications in certification procedures

During the 1952 spraying season nine nurseries sprayed their entire premises with DDT to render their stock eligible for certification to destinations outside the infested areas. These premises totalled 660 acres of nursery plots and border areas.

A revision of the list of products exempt from the certification requirements added a number of forest, stone, and quarry products which are not considered likely to spread gypsy moth infestation under present methods of movement. These lessened restrictions reduced from 600 to 315 the number of producers and operators who ship under certification agreements.

INSECT IDENTIFICATION

Field studies were made in fruit-growing areas of the West Coast by the Bureau's taxonomic specialist on mites. This work resulted in the issuance of a very useful mimeographed report, "A Guide to the Predatory Mites of the West Coast." The studies also supplied information for completing a much needed "Guide to the Spider Mites of Deciduous Fruit Trees." This work also helped field entomologists to understand what may be expected from the various kinds of mites occurring in the western fruit orchards enabling them to more closely synchronize control operations.

Two months' study by a Bureau taxonomist in Alaska developed information showing that mosquito abundance in any one area in Alaska may be predicted from a study of weather data from that area for the previous nine months.

The largest and probably the most important single taxonomic Bureau publication of the year is the Synoptic Catalog of the Hymenoptera of America North of Mexico. This is a work of 1,400 pages that clarified the status of approximately 15,000 different kinds of wasps, bees, ants, sawflies, gallflies, and parasites of other insects. Its preparation involved intermittent work during several years and the cooperation of 17 non-Bureau specialists who contributed the technical material for the particular segments that represented their respective fields of specialization.

A manuscript of approximately 1,600 pages on a "Revision of the American Moths of the Subfamily Phycitinae" is now in final form for publication. A detailed study of the Meyrick Types of Microlepidoptera is also being conducted in cooperation with the British Museum of Natural History. A six-volume work on this subject will be published by the British Museum.

Taxonomists associated with the Bureau identified 87,581 lots of insects, the largest number ever determined in a single year. These identifications assisted in the proper direction of research, control, and regulatory activities.

EUROPEAN INSECT PARASITE INTRODUCTIONS

Several shipments of *Perilitus rutilis* and *Microctonus aethiops*, totalling nearly 1,200 cocoons, and 5 shipments of *Campogaster exigua* totalling 600 females ready to larviposit, were made from France to North Dakota for liberation in fields infested with the sweetclover weevil *Sitona cylindricollis*.

Investigations of the parasites of the European corn borer were continued in Europe during the year. More than 4,300 *Limnerium alkae* cocoons, 2,200 *Microgaster tibialis* cocoons, and 28,500 corn borer larvae containing an estimated 7,100 *Apanteles thompsoni* larvae were shipped to the United States for rearing and colonization in European corn borer infested areas.

Investigations of parasites of the wheat stem sawfly in Europe were started in December 1951 to obtain parasites and ship them to the United States for liberation in wheat fields in the Northwest infested with the wheat stem sawfly.

Seven shipments of more than 600 *Dexilla rustica* females and 5 shipments of more than 500 *Dexilla vacua* females were sent from France for colonization in fields infested with the European chafer *Amphimallon majalis* in New York State. Experiments in France indicate that first stage larvae of both of these parasites are capable of living from 30 to 40 days in the soil while searching for host grubs, and that *D. rustica* has more than 1 generation a year.

Small colonies of *Horogenes fenestralis Microgaster* sp., *Apanteles* sp., *Elactertus* sp., and *Rogas* sp., all parasites of the omnivorous leaf tier *Cnephasia longana*, were sent to Oregon from France during the year for release against this pest.

Several shipments of the elm scales *Gossyparia spuria* and *Lepidosaphes ulmi* were sent from Europe to California for study of the issuing parasites.

Native Parasites Collected for Shipment Abroad

Assistance was given to the European Plant Protection Organization—an organization closely cooperating with the Food and Agriculture Organization of the United Nations—in collecting parasites of the fall webworm in the United States. A limited number of parasites, particularly those attacking the egg stage of this insect, were collected in Connecticut and sent to the Commonwealth Institute of Biological Control in Canada for further processing before forwarding to Austria and Yugoslavia.

WIDESPREAD DESTRUCTION OF KLAMATH WEED BY INSECT PREDATOR

Biological control of the noxious Klamath weed in Humboldt County, California, originally the county most heavily infested with this plant, is now an actuality. At the completion of the 1951 larval feeding period of the insect predators colonized in this county, more

than 100,000 acres of land had been cleared of this nuisance that crowds out desirable forage grasses. The remaining Klamath weeds in the southern part of this county are confined to widely separated, small roadside infestations of about 25 to 30 plants each. Distribution of the foliage-feeding beetles to new localities has been continued. Every county in the State having a Klamath weed problem now contains successful colonies of *Chrysolina gemellata*, originally introduced from Australia. *Agrilus hyperici* and *Zeuxidiplosis giardi*, introduced from Europe in 1950, have now completed 1 year in the field and are definitely established. The work in California was in cooperation with the California Agricultural Experiment Station at Albany.

Chrysolina gemellata has also done very well in controlling the Klamath weed in southern Oregon. It kills the weed readily. The rate of increase indicates that the growth rate of the plant and the life cycle of the insect are well synchronized. Fourteen colonies of this species were introduced into the State of Washington for Klamath weed control there. In Idaho, this species has made excellent progress. It was possible to collect enough beetles in Idaho to start 40 new colonies in weed-infested areas. The University of Idaho reported in November 1951 that an unusually large number of eggs was being found at that time. Approximately 280,000 adults of this species were released in 56 locations in western Montana.

HONEY BEES AND OTHER POLLINATING INSECTS

Wide Variation in Honey Production Among Bee Progeny

Fifteen lines of honey bee progeny at the Madison, Wis., laboratory showed heritable differences in both production and behavior characteristics. The most productive lines produced an average yield of 239 pounds of honey, or 2½ times that of the least productive.

Distribution was made of 1,262 hybrid queens reared on Kelleys Island, Ohio, in the bee-breeding project carried on there in cooperation with the Ohio Bee Improvement Association.

Free-Flying Drones Best for Laboratory Breeding Purposes

When sperm from free-flying drones was used in artificial insemination experiments at Baton Rouge, La., 82 percent of the queens started laying. Out of a group of 68 queens inseminated with sperm from drones that never had a flight, only 44 percent lived to produce eggs. As a consequence emphasis is being shifted to the use of free-flying drones for a sperm supply. During 1951 nearly 900 inseminations were made of 570 queens.

Bee Colonies Survive Prolonged Low Temperatures

Two colonies of bees placed in a deep-freeze unit at the Madison laboratory on July 30 survived 6 to 7 weeks at temperatures of −40° to −50° F. These tests were preliminary to experiments on wintering bees in electrically heated hives under a cooperative project with the Division of Farm Electrification, Bureau of Plant Industry, Soils, and Agricultural Engineering.

Time-Saving Technique for Diagnosing Foulbrood Developed

An improved method of preparing a water mount for the microscopic diagnosis of American foulbrood has been developed at the Beltsville, Md., bee culture laboratory. A coverslip containing a stained smear is inverted on a glass slide covered with a film of immersion oil. This results in the water on the coverslip becoming entrapped in the form of droplets in the oil. If spores of *Bacillus larvae* are present, they will be concentrated in these droplets. Advantages of this method are simplicity of preparation, ease of locating the concentrated spores, and elimination of "streaming" of spores. It also saves time since the mounts do not dry out; many slides can be prepared at once and their examination delayed several days.

In other work at Beltsville, differential media were devised for distinguishing between various organisms associated with European foulbrood. For example, addition of 2,3,5-tetrazolium chloride to nutrient agar antagonism plates increases the ease with which these plates may be read and improves their use for diagnostic purposes. In such a media *Streptococcus apis* grows as a deep red, compact colony. *Bacillus alvei* and *B. para-alvei* still grow as spreaders but at a reduced rate. However, *B. alvei* colonies have a light pink, smooth center, surrounded by a white zone and then a pink zone. *B. para-alvei* colonies have a dark pink granular center surrounded by a light pink zone, then a clear zone, and finally an orange-pink zone.

Hybrid Queens Produce Colonies Highly Resistant to American Foulbrood

Tests for resistance to American foulbrood were made on three groups of colonies at Laramie, Wyo. These colonies were headed by 4-way hybrid queens produced in 1950 on Kelleys Island in Lake Erie. These queens carried the blood of resistant strains. All showed high resistance to American foulbrood. One group of 9 colonies remained free of disease. In a second group of 15 colonies only 1 developed disease but quickly recovered. In a third group of 7 colonies 6 remained disease-free, but one colony contracted disease and had not recovered when winter set in. The first two groups also showed remarkable colony development and very good surplus honey production.

Pollinators of Cotton Blossoms in Arizona Identified

Honey bees and native bees of the genus *Melissodes* were found to be the chief insect visitors of value as pollinators of cotton blossoms in Arizona. Bees of the genus *Elis* for the most part visited extra-floral nectaries. Wasps in the main visited leaf nectaries. Although honey bees collected nectar primarily and contacted the stigma accidentally when entering or leaving the flower, *Melissodes* primarily collected pollen and is, therefore, a more effective pollinator. In cages with a high concentration of bees per plant, honey bees collected cotton pollen without difficulty, indicating that they could be effective pollinators under proper conditions. Using honey bees in cotton pollination will probably require concentrations of colonies in the field similar to that recommended for alfalfa seed production.

Honey Bees Affect Cotton Flower Development

In studies on cotton pollination made in Arizona, flowering cotton was enclosed in large plastic screened cages. In some of the cages colonies of honey bees were placed. Bees were excluded from other cages. In the cages with bees all the new (white) flowers that opened on any one day were pink by 5 p. m. and almost completely closed. In the cages without bees the new flowers were still white and flared open. This may be a factor of practical importance to cotton growers in areas where afternoon showers are common, since earlier closing of the flowers should afford increased protection to the stigma. It may also be a guide to cotton breeders in determining the proportion of natural crossing in open fields.

Huge Numbers of Bumble Bees Assist in Pollinating Red Clover

At Columbus, Ohio, the largest bumble bee population observed in several years was of material help in pollinating red clover, supplementing the work of honey bees moved into the field. Unfortunately, there is no means at present of maintaining the number of bumble bees from year to year at a constant level.

Competitor Plants Reduce Effectiveness of Bees as Red Clover Pollinators

Competitor plants can greatly reduce the effectiveness of honey bees in the pollination of red clover. In Delaware County, Ohio, for example, difficulty was experienced in obtaining adequate pollination of red clover by honey bees since nearby ladino clover attracted most of the pollen-collecting honey bees while nectar-collecting bees visited alfalfa. Even increasing the number of bees to 7 colonies per acre did not entirely correct the difficulty because of the large acreages of the competing plants.

Improved Harvesting Methods Necessary to Reap Benefits of Bee-Pollinated Red Clover

Harvesting losses of red clover seed in Ohio were heavy although weather conditions were unusually favorable for such operations. In one instance it was found that the combine discarded into the refuse 43 percent of the seed in the field. Such losses, or greater ones, appear to be the rule. Consequently, it seems certain that with the use of adequate numbers of honey bees for pollinators, red clover seed production in Ohio could be increased from 50 to 100 percent by a moderate improvement in harvesting efficiency.

Insect Pollinators of Alfalfa Vary with the Locality

Field studies in Nevada, Utah, and Washington showed that insect pollinators of alfalfa vary with the locality. In the lower Yakima Valley of Washington, southern Millard County of Utah and in the Uintah Basin, alkali bees (*Nomia*) were the principal pollinators. In the Delta tract of Millard County, honey bees were the principal pollinators, except for scattered localities containing *Nomia* nesting

sites. In Washington County (southwestern Utah) a complex of wild bees and pollen-collecting honey bees were all important and doing a good job. In south-central Utah and an adjacent area of Arizona, honey bees (from 1 to 5 percent pollen collectors) and bumble bees (*B. morrisoni*) were responsible for a moderately good pollination job.

Alfalfa Pollen Varies in Attractiveness to Bees

It is increasingly evident that differences exist between varieties in fields of alfalfa which affect bee collections of both nectar and pollen. Among several varieties of alfalfa observed in Kern County, Calif., one was practically devoid of pollen-collecting honey bees early in July, although such bees were numerous on the other varieties. Since pollen collectors are highly efficient trippers of the blossoms, a poor set was being obtained on this one variety. Later in the season, however, as the other varieties became bent down with seed and decreased in attractiveness, the bees collected pollen from the previously neglected variety, which was still in good blossom. All these fields were supplied with about 3 to 4 colonies of bees per acre for the purpose of increasing seed set.

Fewer Bees Needed for Alfalfa Pollination in Absence of Competitor Plants

Plants that compete with alfalfa as a source of pollen are scarce in the San Joaquin Valley as compared with the Sacramento Valley of California, a situation which would indicate a more rapid seed set and the need for fewer bee colonies to accomplish pollination of an acre of alfalfa in the former than in the latter valley. Observations this past summer bore out this assumption. It was found that at Bakersfield as few as 3 colonies per acre set heavy yields of seed in 30 days, whereas at Woodland even 6 colonies per acre required 60 days or more to set a heavy crop. The bees collected only nectar at Woodland. When bees visit alfalfa simply for nectar, their efficiency in effecting pollination of this plant is low. Yields of 500 to 1,000 pounds of alfalfa seed per acre were nevertheless obtained from many fields in both localities.

COTTON INSECTS

Pink Bollworm Control and Research Activities

Widespread dispersion of pink bollworm poses serious threat

Never before in the 35 years since the pink bollworm first entered the cotton fields of Texas has the situation been so serious as it is now. There has been an alarming spread in recent years of this most destructive cotton pest. Farmers, educators, extension and research agencies, and the entire cotton industry are being urged to form a unified team to carry out the recommended control program in a manner to again suppress it and to keep it below a level where commercial damage results. The life history of the pink bollworm is such that it is much more susceptible to cultural control measures and cottonseed heat treatment than many other cotton pests.

Effective, large-scale pink bollworm control, for example, revolves around the fact that the insect goes into winter hibernation in cotton bolls left in the field where the insect developed or in untreated cottonseed from that field. These two facts render this species especially vulnerable to field cultural practices or to a relatively simple cottonseed heat treatment at the gin. These are relatively inexpensive operations. The object of field cultural practices is to check development of pink bollworms in the fall and to destroy all bolls left in the field after harvest. Such practices include early shredding, cutting, and plowing under of all crop residue before the pink bollworms can go into hibernation. Cottonseed heat treatment consists of the application of moist or dry heat to cottonseed at a temperature of 150° F. for a period of 30 seconds.

A combination of such cultural control and cottonseed heat treatment, effectively enforced through State and Federal cooperation, has for many years confined the pink bollworm to parts of five States, with commercial damage limited to a few border counties in Texas. It is estimated that the pink bollworm has never until 1951 accounted for the destruction of more than one bale in each thousand produced in the United States. Other cotton insects have occasionally destroyed one bale out of each seven.

A further estimate shows that during the 35 years these control measures have been practiced, the gin and oil mill industry and the farmers have invested no more than $15 million in equipment for pink bollworm control. Farmers in a pink bollworm infested area pay about 25 cents an acre for cottonseed treatment. Furthermore, State and Federal combined control and research activities on the pest have cost less than $30 million. On the other hand control of other cotton insects is estimated to have cost the farmer more than 1 billion dollars in equipment and insecticides during the same span of years, with several billion dollars' worth of cotton destroyed by these insects.

Were it necessary similarly to apply insecticides to the entire cotton crop for pink bollworm control, following current research recommendations and attaining only partial kill, it is estimated that the annual cost would be a half billion dollars.

Although infestation in many south Texas counties was fairly light at the beginning of the 1951 crop, it later built up to the heaviest ever recorded in that section. Commercial damage occurred in many fields. A light infestation persisted in counties found infested in the 1950 crop in north-central Texas and in the Oklahoma regulated area. Infestation in 1951 was generally lighter in the western part of Texas, New Mexico, and in the Torreon and Delicias areas of Mexico. Only one pink bollworm was found in the regulated area of Arizona. A light infestation recurred in Vermilion Parish, La., but none was found in the other parishes under regulation. Area-wide inspection activities in 1951 showed further spread of this insect to 17 counties in Texas and two counties in Oklahoma, east of the previously infested counties. It was also necessary to reclassify, from lightly to heavily infested, 33 Texas counties.

Build-up and dispersion of pink bollworm infestation in the past two years has resulted because known control measures were not applied in a number of important cotton growing counties. This per-

mitted establishment of a heavy local infestation. From these heavy, localized infestations wind currents probably carried moths of the insect for long distances, thereby establishing infestations in counties that have never before been invaded.

Failure to apply the measures that would have kept the pink bollworm under control are attributable to a variety of circumstances. Weather conditions in some instances were unfavorable for meeting the State-imposed planting dates and extensions of planting dates were granted. Maturing cotton in fields adjoining this late planted cotton furnished a reservoir of pink bollworms to heavily infest the overlapping crop. Arid field conditions preceding crop maturity combined with favorable temperatures and winds then permitted the moth of the pink bollworm to be wind-borne and thus dispersed northward and eastward to uninfested counties.

When this mode of dispersal was coupled with later extensions of State-imposed dates for cotton stalk and debris destruction, pink bollworms in heavy concentrations went into winter hibernation right in the fields. For example, 50,000 farmers and some 3 million acres of cotton were involved in the 1951 pink bollworm cultural control program in Texas and Louisiana. More than a million acres of the Texas plantings were standing beyond the stalk destruction dates. Such extensive failures to plow under the stalks resulted in delayed crops. Enormous numbers of pink bollworms overwintered in these late-maturing bolls. There was a lower than normal mortality of overwintering worms in south Texas, with a consequent abnormally high potential for early 1952 crop infestation.

In the Eagle Pass, Tex., area, for example, late planted fields in 1951 were very heavily infested. One farmer is reported to have picked only 18 bales of cotton from 162 acres. Another farmer cut and plowed several fields on his farm when he found he had nearly a bale per acre of heavily infested green bolls. Field inspection reports from this area late in September 1951 showed that 67 percent of the bolls examined were infested, with an average of nearly four pink bollworms each. At this same time, seven fields were found to be 100 percent infested, some bolls containing as many as 18 to 20 worms.

Inspection of surface debris through the winter of 1951–52 and into April confirmed the presence of heavy infestation in all south Texas counties as far north as San Antonio. Survival in these counties ran well over 50 percent. About 25 percent survival was found in the west Texas Counties of Howard, Martin, and Midland. Everywhere inspections have been made in Texas thus far in 1952 increased infestation has been found. In 1951, for example, 47,000 bolls from surface debris collected in 47 Texas counties yielded some 1,900 worms. Inspections in 1952 of 52,000 such bolls from 55 Texas counties showed nearly 22,000 worms. Bloom inspection of the 1952 Texas crop gave an early indication of the pink bollworm infestation that might be expected—a threefold to fourfold increase in infestation over 1951 was apparent in many counties. Examination of green bolls of the 1952 crop made by the end of the fiscal year showed a heavy infestation of pink bollworms in 70 out of 85 fields examined in four Rio Grande Valley counties.

In contrast to the heavy buildup of infestation in Texas the situation in Louisiana—where a noncotton zone was imposed in infested

parishes, and strict planting and plowup dates were enforced in surrounding areas—is greatly improved. Whereas 1951 inspections in 2 parishes showed 17 worms in 102 bolls, 788 bolls examined in 1952 failed to disclose a single worm. Bloom inspection in 12 parishes of the State also failed to show any pink bollworm infestation. Stalk destruction was completed on schedule in Louisiana except in a few individual cases. Ten pink bollworms were found during 1951 gin trash inspection in Vermilion Parish. These were traced to two fields south of Abbeville. These fields and others in the vicinity were given three airplane dustings of insecticides and stalks were promptly destroyed. This area, comprising about 250 acres, will constitute a noncotton zone during 1952. The noncotton zone effective during 1951 in parts of Cameron and Calcasieu Parishes, La., was lifted in 1952 and cotton planting permitted there, since all inspection in these parishes showed the control measures to have been effective in eradicating the infestations found there in 1950.

Pima and Santa Cruz Counties, Ariz., having been found free of pink bollworm infestation for a number of years, were removed from the infested area. Thurberia weevil quarantine No. 61 that included Santa Cruz and part of Pima County was also rescinded, effective April 18, 1952, since years of observation indicate that this insect will not become an important pest of cotton in the arid sections of cotton-growing States as was originally feared.

During 1951, 25,000 Mexican farmers growing some 1,500,000 acres of cotton cooperated in applying cultural controls in northern Mexico. This served to prevent the buildup of large numbers of pink bollworm in areas south of the Mexican border which in turn could spread to uninfested areas of the United States. Two hundred gins and a number of oil mills and compresses processed nearly 1 million bales of cotton according to prescribed standards for pink bollworm control. There were some late planted fields in the border area in which there was considerable persistence of infestation and increased carry-over of hibernating larvae.

Following the discovery of a few live pink bollworms in steam-treated, mechanical cotton pickers that had been transported from south Texas to California, all additional machines to be moved were subjected to thorough fumigation before leaving the infested area.

As part of the total 1951 inspection program, inspections were made in Alabama, Arizona, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, New Mexico, Oklahoma, Texas, the border areas of Mexico, and in Sonora and Sinaloa, on the west coast of Mexico. Some 11 million cotton blooms, 149,000 bolls, and 51,000 bushels of gin trash were inspected from the 1951 crop.

The year's quarantine activities involved supervision of treatments and certification of cotton grown on more than 12 million acres with a production of nearly 4½ million bales. Nearly 150,000 certificates and permits were issued to cover the movement of cotton products from more than 2,000 gins, 117 oil mills, 9 separate heat-treating plants, 164 compresses and warehouses, and one vacuum fumigation plant. One and three-quarter million tons of cottonseed were heat-treated at gins, oil mills, or other plants to kill pink bollworms. More than 100,000 tons of these received a second heat-treatment before shipment from heavily infested area.

Greater emphasis given to pink bollworm research problems

Hibernation tests and field observations have confirmed the effectiveness in mild, humid regions, such as the south Texas area, of cultural control methods developed by previous research and now practiced in the pink bollworm infested area. These showed that the most effective means of reducing pink bollworm carry-over is to shred the stalks as soon as picking is completed and later plow the crop debris under as deeply as possible. Winter irrigation to hasten destruction of cotton debris also reduces the carry-over. Where winter temperatures of 10° F. or lower usually occur, stalks should be left standing to be plowed under as deeply as possible in late winter or early spring.

Other hibernation tests showed that the pink bollworm survived the winter in free cocoons in the soil at Eagle Pass, Tex., and in similar arid regions of west Texas. Pink bollworms survived the winter in open bolls in three consecutive years in hibernation tests at Big Spring, Howard County, in the south plains area of Texas. No survival, however, occurred in free cocoons in the soil in the Lower Rio Grande Valley of Texas and Mexico, where the winter is mild and humid. Field observations showed that the pink bollworm will breed throughout the year in the Lower Rio Grande Valley if fruiting cotton is available.

Use of the new, improved stalk cutters or shredders to cut stalks into small pieces, followed by a flat-broken plowing job has been found to give a more thorough coverage of crop debris and a lower pink bollworm carry-over. Early uniform planting, early control of thrips and fleahoppers, and close spacing also stimulate earlier crop maturity and less insect damage. Further, where the stalks were cut during extremely hot, dry weather in the south Texas area and the bolls exposed on the soil surface, more than 90 percent of the pink bollworms were killed by an exposure of from 4 to 6 days at a maximum soil surface temperature ranging from 140° to 150° F.

By planting fast-fruiting, quick-maturing varieties of cotton, research workers have been able to avoid some of the damage from the seasonal buildup of pink bollworm infestation.

Chemical defoliation of the cotton plant has proved to be an effective means of reducing the late seasonal buildup of infestation, the overwintering worms, and the amount of damage to the crop. Defoliated cotton is usually picked more closely, which also contributes to a lower carry-over.

DDT continues to show the most effective chemical control of the pink bollworm. Tests show that EPN also gives some control and that a formulation containing EPN and DDT may be a good combination material for control of the boll weevil, bollworm, spider mites, and pink bollworm where all these pests occur in the same field. DDT combined with either BHC, toxaphene, aldrin, dieldrin, or with neutral calcium arsenate plus parathion, gave satisfactory control of the boll weevil and pink bollworm in fields infested with these two species. In the Laguna area of Mexico—where the pink bollworm has been a pest for 40 years—a major factor in its control is the use of insecticides containing DDT. It is reported that 8,000 tons of insecticides were used there in 1951.

Thirteen species of wild malvaceous plants have been found infested with the pink bollworm in South Texas. Abundance of infestation

in these alternate hosts is dependent on the proximity of the plants to infested cotton, intensity of the infestation in cotton, and the fruiting condition of these plants at the time the cotton is destroyed.

Thus far chemical treatment of the soil has not proved an effective or inexpensive means of controlling the pink bollworm. Of the various insecticides tested, DDT and BHC have given the highest larval kill. Dosages needed for any appreciable kill, however, would be too costly.

Greater impetus will be given to pink bollworm research in the next fiscal year. A tentative allotment of $110,000 of Bureau funds has been made to that activity through a shift of funds from less urgent problems. Matching funds are being sought from several State and nongovernmental sources. Plans are also being developed for an expanded 5-year research program.

Many Florida localities freed of wild cotton host plants

Work aimed at eradication of the pink bollworm in South Florida was effective in freeing many localities of wild cotton host plants. Searches for such wild cotton plants in inaccessible coastal and island areas covered more than 11,000 acres and resulted in destruction of some 30,000 wild cotton plants. Four percent of the plants destroyed had matured fruit. Examination of 9,400 bolls, blooms and squares from these plants showed a very low pink bollworm infestation—only 73 larvae having been found. The previous year 571 pink bollworms were found during the examination of 13,500 fruiting forms. In addition to the survey for wild cotton plants, 676 dooryard locations were checked and 3,085 dooryard cotton plants removed from 410 of them. Scouts engaged in this work found 346 pink bollworms in some 19,000 fruiting forms collected from dooryard cotton plants.

Many small locations were found entirely free of wild cotton plants. That part of Florida north of the Cape Sable area on the West Coast and Broward County on the East Coast were found free of pink bollworm infestation, thus assuring a safety zone between the surveyed area and the domestic cotton-producing area farther north.

As a result of the discovery in Texas that kenaf—a fiber crop new to this country—is a host of the pink bollworm, the Florida survey crew inspected a large kenaf acreage adjacent to known pink bollworm infestations. A method of inspecting such seed for pink bollworm was developed. Several hundred pounds of seed was inspected and found free of infestation.

Less Boll Weevil Damage to Cotton Crops

Widespread use of large quantities of insecticides early in the 1951 growing season combined with hot, dry weather from June to August resulted in much less damage to the cotton crop than in either 1949 or 1950.

The general cotton insect survey in 1951 included specific counts on the boll weevil and other cotton pests. Plant inspections were made early in the season and the regular square infestation counts were made during the cotton fruiting period. The survey during the 1951 growing season showed that the weevil survived the winter in sufficient numbers to cause serious damage in most areas where it occurred in

1950. It survived throughout Oklahoma and Arkansas and also in parts of Tennessee, North Carolina, and Missouri.

Cotton insect investigations were continued at Bureau laboratories. Much of the work was in cooperation with agricultural experiment stations in the respective States in which the work was done.

Insecticides for Cotton Insects Screened at Texas Laboratory

Promising new insecticides tested at the basic research screening laboratory in Texas against the boll weevil and other cotton insects included endrin, isodrin, methyl parathion, Metacide, malathon, compound 1795, compound Q–129, insecticide 3960–X14, and dimethyl potasan. Field tests with several of these new insecticides were in progress in 1952 to establish satisfactory dosage levels.

In early-season control experiments in Texas 7,000 acres of cotton were treated with sprays containing either toxaphene or aldrin. Four applications were made between May 14 and June 9. The seasonal boll weevil infestation in the treated fields averaged 3 percent as compared to 20 percent for an adjacent untreated area. Bloom counts showed that early-season treatments had greatly accelerated fruiting.

Light Bollworm Damage to Cotton Crop

Comparatively light damage to the cotton crop from the bollworm occurred in 1951 although serious localized outbreaks were reported, especially in Arizona, Mississippi, Texas, Oklahoma, Louisiana, and Arkansas. A severe outbreak of various lepidopterous larvae, chiefly the bollworm, *Heliothis armigera* (Hbn.), and the tobacco budworm *Heliothis virescens* (F.), was reported in Mississippi during the latter part of June and July. In both Mississippi and South Carolina the tobacco budworm was more abundant on cotton than the bollworm.

In Mississippi the bollworm was more abundant on alfalfa and milo than on any other crops, indicating that they may be of value as trap crops.

DDT continues to be the most effective insecticide yet known for the control of the bollworm. It may be used in mixtures with other insecticides where other insects, as well as bollworm, require control. In tests in Mississippi, DDT applied at 0.5 pound per acre when the bollworm eggs were hatching was sufficient to give effective control. After the bollworms were large and had entered the bolls higher dosages were required. Toxaphene proved to be the next most effective insecticide against the bollworm. Toxaphene applied as a dust gave better control of bollworms than toxaphene spray. Bollworm control was improved where DDT was added to toxaphene spray mixture at the rate of 0.25 to 1.0 pound per acre. Bollworms were usually controlled where 0.5 pound or more of DDT per acre was applied with benzene hexachloride, aldrin, dieldrin, heptachlor, or toxaphene in the regular schedule for boll weevil control.

In Texas no control measures were needed for the bollworm in fields in which early treatment for other injurious insects did not extend beyond June 15. Bollworm egg deposition was heavy in many of these fields but beneficial insects were abundant and prevented the development of damaging infestations. In these experiments the natural enemies of the bollworm appeared to have had ample time to

reestablish themselves during the period that elapsed after the last early-season application was made and at the time when bollworms began to develop. Heavy infestations did occur in a few fields which received treatment beyond June 15.

Cotton Aphids Easily Controlled

Surveys conducted over most of the Cotton Belt showed that the 1951 aphid infestation was light. Damage to cotton by various root aphids has greatly abated in South Carolina since the use of organic insecticides for control of the boll weevil, due chiefly to the control of ants attending them.

Combinations of insecticides to prevent aphid buildup were tested in numerous field plots. In Mississippi it was found that the use of aldrin, dieldrin, toxaphene, or heptachlor for boll weevil control did not cause aphids to increase unless DDT was mixed with it. When DDT was included in the spray formulations for bollworm control, 0.5 percent or more of compound 923, benzene hexachloride, EPN, or parathion, prevented an increase in aphids. Also, two new promising insecticides for boll weevil control, endrin and isodrin, did not cause an increase in the aphid population unless mixed with DDT. Since endrin showed promising results against the bollworm, DDT may not need to be formulated with this material.

Cotton Fleahopper Unusually Scarce

Cotton fleahopper and related insect infestations were usually light throughout the 1951 growing season in the 12 cotton-growing States included in the survey. The heavy poisoning schedule maintained for boll weevil, thrips, bollworms, and other cotton pests apparently helped to hold the cotton fleahopper in check in most areas.

Effective Controls Developed for a Variety of Cotton Insects

Serious infestations of the garden webworm, yellow-striped armyworm, fall armyworm, and other lepidopterous larvae requiring control measures, developed over large areas of Texas, Mississippi. Oklahoma, and other States. Spider mite infestations were more general than usual and serious infestations developed in all cotton-growing areas. Although the cotton leafworm is usually a serious pest in many South Central States, no infestations developed to require control measures in 1951. Thrips and cutworms caused considerable damage to cotton in Texas, Oklahoma, Mississippi, and South Carolina.

Effective control of the garden webworm was obtained with toxaphene, DDT, parathion, dieldrin, or aldrin; promising new insecticides tested included endrin, Metacide and Systox.

EPN was found to be the most effective insecticide tested against the yellow-striped armyworm. If applied in the early stages of development, good control was also obtained with toxaphene, DDT, dieldrin, TDE, parathion, and with toxaphene plus DDT.

Good control of the fall armyworm was obtained with toxaphene, chlordane, DDT, dieldrin, aldrin, benzene hexachloride, or endrin.

In Texas TEPP, parathion, and malathon gave a high initial kill of spider mites, but the infestation built up again within 5 to 9 days.

Promising results were also obtained with Systox, compound 923, OMPA, Metacide, and methyl ester parathion.

The most effective materials tested against the variegated cutworm in Mississippi were endrin, TDE, DDT, and toxaphene. In Texas excellent control of the pale-sided and granulate cutworms was obtained with toxaphene and toxaphene plus DDT; less effective materials included parathion, chlordane, and dieldrin.

It was found that all of the formulations recommended for use against the boll weevil also gave excellent control of thrips at approximately one-half to one-third of that dosage. These materials include toxaphene, benzene hexachloride, heptachlor, aldrin, chlordane, and dieldrin.

Fundamental Properties of Cotton Insecticides Studied

In field-cage and laboratory tests conducted at College Station, Tex., in cooperation with the Texas Agricultural Experiment Station it was found that calcium arsenate, toxaphene, and dieldrin had longer residual properties against the boll weevil than benzene hexachloride, aldrin, chlordane, or heptachlor, although the action was slower.

Heptachlor, dieldrin, aldrin, and chlordane, each killed a high percentage of boll weevils developing inside cotton squares. Benzene hexachloride was much less effective in this respect than the other materials.

Applied at one-third pound per acre EPN was effective against the boll weevil in laboratory and field-cage tests but failed to give control in some field experiments. It also failed to kill boll weevils inside cotton squares.

After two dust applications the average total insect population over a period of about one month was reduced, as compared to the untreated check, by the following percentages: Dieldrin 80, aldrin 77, DDT 75, toxaphene 74, benzene hexachloride 66, EPN 61, and parathion 58.

After three spray applications, the average total beneficial insect population over a dry, hot period of about 2 months was reduced under that of the untreated check by the following percentages: Toxaphene 17, aldrin 3, and dieldrin 11.

When used against the garden webworm EPN, parathion, and methyl parathion each gave 86 percent mortality or higher at rates of one-third pound or less per acre in cage tests.

Of eight materials tested in cages against the salt-marsh caterpillar, EPN and parathion each caused a mortality of more than 90 percent at one-half pound per acre.

EPN at one-third pound per acre was the most effective of 16 materials tested against the yellow-striped armyworm.

New chemicals tested against the boll weevil included endrin, methyl parathion, insecticide 3960–X14, malathon, Metacide, compound 1795, dimethyl potasan and compound Q–129.

New chemicals tested in the laboratory against the cotton aphid included OMPA, Systox, malathon, and dimethyl potasan.

Biochemical investigations to determine the manner in which insecticides kill various cotton insects, showed that the fat content of the boll weevil increases as the season progresses and, as a rule, the toxicity of the chlorinated hydrocarbons decreases. Field collected boll weevils averaged about 6 percent fat in June and increased

to approximately 16 percent in August. When the type of fat was correlated with toxicity data, it was found that the percent of linoleic acid apparently had a greater inverse relationship to percent kill than the total fat or any of the other components.

Systemic Chemicals Tested Against Cotton Aphid and Spider Mites

Of 100 chemicals tested, 20 were found to possess systemic insecticidal properties against the cotton aphid and spider mites. Eight of these were more effective than OMPA. The most effective systemic insecticide tested was Systox. This was about eight times more effective against aphids and spider mites than OMPA when applied as a seed treatment. Systox also killed these pests both by contact and as a fumigant. Systox killed cotton leafworm larvae and thrips by contact action, but it did not show any systemic properties against these insects. It was not effective against the boll weevil, bollworm, yellow-striped armyworm, or the salt-marsh caterpillar.

INSECTS AFFECTING MAN

Development of Insecticide Resistance Complicates Mosquito Control

In cooperative investigations with the Bureau of Vector Control, California Department of Health, it was found that the difficulty in controlling mosquitoes in certain irrigated regions in that State was explained by the appearance of strains of mosquitoes highly resistant to DDT.

Laboratory evaluation of new mosquito larvicides shows that EPN, an organic phosphorus compound, is one of the most effective materials available. It is equal to or superior to DDT against the common species occurring in the Northwest. However, the high toxicity of the compound to warm blooded animals may limit its usefulness in mosquito control. New effective larvicides are now urgently needed in the Western States, particularly in California. *Culex tarsalis*, *Aedes nigromaculis* and *A. dorsalis* have, during the past 5 years, developed tolerances to DDT as much as 10 times that of strains of normal susceptibility. Moreover, where toxaphene and aldrin have been substituted for DDT, *C. tarsalis* larvae have within 2 years developed a marked resistance to these materials. The resistance problem is also acute in Florida and in other places in the United States. The problem parallels the difficulties now being experienced in connection with the control of house flies and body lice.

Important progress was made in developing practical ways to control adult mosquitoes in the Northwest. Due to the presence of many mosquito breeding areas in mountainous regions, often located in almost inaccessible terrain, it has been impractical to attempt control by larviciding. Moreover, the mosquitoes migrate long distances, so that destruction of larvae in limited areas may not accomplish satisfactory control. During the past year investigations demonstrated that the application of 1 or 2 pounds of DDT in residual sprays to all vegetation to a height of about 10 feet in the vicinity of homes and resort areas provided almost complete relief from mosquito annoyance

during daylight hours. However, at dusk and for an hour or two after dusk the mosquitoes migrate freely. At such time they may fly into the treated area and cause severe annoyance before they come in contact with treated surfaces.

Several Insecticides Effective in Controlling Fire Ants

The imported fire ant, found in the Southern States, particularly Alabama and Mississippi, is an annoying pest of man and animals and is also destructive to certain agricultural crops. Surveys during the past 3 years have shown that the pest is also present in Georgia, Louisiana, Texas, Florida, South Carolina, Tennessee, and Arkansas.

Further research has been conducted to develop improved methods for controlling the pest. Chlordane emulsions containing 0.37 percent chlordane applied to individual mounds at the rate of about 3 gallons per average mound having a diameter of 3 feet, will usually destroy the colony, although follow-up treatments with about 1 gallon for each surviving colony may be required. When applied on an area basis 2 to 4 pounds an acre of chlordane will usually eliminate all colonies.

Research under way indicates that aldrin is equally as effective as chlordane and that dieldrin may be about twice as effective as chlordane.

INSECTS AFFECTING ANIMALS

New Approach to Screw-Worm Control Being Tested in the Field

In efforts to develop methods for eradicating screw-worms from restricted areas, particularly in the Southeastern States, an entirely new approach to insect control is being investigated. Laboratory investigations during the past 2 years have demonstrated that when pupae of the screw-worm are exposed to 5,000 roentgens of X-rays, flies that subsequently emerge are not seriously affected from the standpoint of activity and length of life but they are incapable of reproducing. The sterile males will mate with normal females and such mated females deposit infertile eggs. A significant point is that the females of this insect mate only once even when mated to X-ray sterilized males. It has been shown by tests in laboratory cages that the sterile males compete successfully with normal males. Tests on caged screw-worm populations containing 10 normal females, 10 normal males, and 90 sterile males show that approximately 90 percent of the females lay infertile eggs. This is in line with the percentage of sterile eggs that would result from chance, assuming all males are of equal vigor.

Preliminary studies on natural screw-worm occurrence have indicated that the average number present during the winter months is relatively low and that it might be economically feasible to rear, treat to cause sterility, and release enough flies to start with a ratio of 10 sterile flies to 1 naturally occurring wild fertile fly.

In view of these encouraging results in the laboratory, investigations are now underway in the field to determine if the release of large numbers of sterile flies in an area will cause female flies to lay eggs which do not hatch.

Preliminary studies conducted in cooperation with the Oak Ridge, Tennessee National Laboratory, under contract with the Atomic Energy Commission, indicate that gamma rays from radio-active cobalt have the same effect on flies as do X-rays. This method of causing sterility would be much more practical than X-rays. Cooperative studies with a commercial electric company also indicate that cathode rays will cause sterility of the flies.

Dips Evaluated for Control of Cattle Ticks

Most of the research on control of ticks on cattle has been devoted to the evaluation of dip formulations of toxaphene and DDT-lindane wettable powder preparations. Much of this work was done in cooperation with commercial companies. Toxaphene (0.5 percent) and DDT-lindane (0.5 percent DDT-0.025 percent lindane) formulations are now recommended for use as sprays. However, when vats are charged with them they tend to deteriorate, resulting in decreased efficacy and greater hazard to the animals. A considerable number of cattle have been killed in Texas, Florida, and in Central America because toxaphene emulsion dips have deteriorated in vats within a few weeks or months after they were charged. Basic studies on the cause of such deterioration have been undertaken. By microscopic examination of the dips at regular intervals during the season, following routine dipping of cattle, sheep, and goats, it was noted that the emulsion particles tend to coalesce. Samples of hair from dipped cattle were also analyzed for toxaphene following each dipping. These studies showed that as the emulsion particles became larger there was an increase in the amount of toxaphene deposited on the hair of the dipped animals.

Two commercial preparations of emulsifiable toxaphene are under study. From the standpoint of stability in vats these are much superior to other products marketed in the last few years.

Improved Sprays for Controlling Flies Affecting Livestock Sought

In further research on the control of horn flies a new insecticide known as Q–137 (1,1-dichloro-2,2-bis (*p*-ethyl phenyl)) has been evaluated on cattle. It appears to be equal in efficacy to methoxychlor, DDT, toxaphene and other insecticides now used for controlling this pest. No information is available, however, as to whether the insecticide accumulates in fat of cattle or is excreted in milk in hazardous quantities.

A series of tests with DDT for horn fly control in Florida on herds of cattle indicate that the insect has not acquired any significant resistance to DDT in these areas. The same concentration and amount of DDT used in 1945 were applied in 1951. The periods of effectiveness of the treatments were approximately equal.

A search for new insecticides and repellents for the stable fly have continued. Sulfoxide and *n*-propyl isomer were tested in combination with pyrethrum and applied as mist sprays to cattle. These two synergists, which step up the potency of the insecticide, were equal in performance to piperonyl butoxide. It was noted that the degree of protection afforded was extremely variable, depending apparently on the prevailing temperature and amount of sunshine.

Radio Isotopes Used To Study House Fly Dispersal and Insecticidal Resistance

Further studies were made to obtain more information on the rate and distance of dispersion of flies marked with radio isotopes. House flies and black blow flies were marked with radioactive phosphoric acid. These investigations demonstrated that flies disperse rapidly and cover long distances within a few days. Black blow flies were recovered 16 miles from the release point within 48 hours. The maximum distance of recovery of this species was 28 miles. House flies did not migrate as far but were found to fly long distances. One was taken 20 miles from the point of release. This apparently is the longest flight recorded for this insect. The information on the rate and extent of spread of flies has an important bearing on spread of diseases, spread of resistant insects, and source of flies in different areas.

Radioactive DDT was utilized in efforts to develop information on the mechanism of insecticide resistance in flies. Other studies showed that flies killed by exposure to DDT residual deposits had absorbed less DDT than those killed by applying the DDT to the thorax. Studies on relationship of temperature to the amount of DDT absorbed by flies showed that more DDT was absorbed at temperatures of 90° F. than at lower temperatures. The mortality of flies, however, was found to be greater at lower than at higher temperatures, indicating that temperature has even greater effect on the efficacy of DDT than previously believed.

Agricultural Products Tested as Fly Attractants

In efforts to develop attractants for house fly control, a large number of agricultural products were evaluated. Fermenting products such as molasses, brown sugar, malt, and certain fruits will attract flies but their degree of attractiveness is extremely variable. A number of synthetic organic compounds show attractiveness in the laboratory but none of these have been explored sufficiently to determine their practical value. The use of liver baits in traps set around slaughter houses decreased the blow fly population about 85 to 95 percent in one test.

Rotenone Still Most Effective Control for Cattle Grubs

Several hundred insecticides were evaluated for the control of cattle grubs. None of these were equal to rotenone insecticides. Recommendations for controlling cattle grubs with sprays have called for equipment delivering at least 400 pounds pressure. Studies during the past year have shown that equipment delivering 200 pounds pressure will provide satisfactory control of third instar larvae. These studies were conducted in Oregon in cooperation with Oregon State College and in Texas and Georgia.

Efficacious Control for Mites and Lice Affecting Poultry Found

Further investigations during the past year have demonstrated the efficacy of lindane insecticides for controlling mites affecting poultry. Concentrations of 0.5 percent lindane applied thoroughly to all wall

surfaces, cracks, crevices, roosts and other possible hiding places for common poultry mites will assure excellent control. Such treatment will also control lice on poultry. Control of the lice results from the vapor action of the lindane. Studies are under way to determine if the use of lindane as a treatment for litter in poultry houses causes any adverse effects on young chickens.

Studies of Toxicological Effects of Insecticides on Animals Intensified

Research studies were continued and intensified to determine the degree of storage of insecticides in meat and milk of beef and dairy cattle when insecticides are applied for external parasite control. The work on all phases of the project is carried out in cooperation with the Bureau of Animal Industry. Various commercial companies and the Texas and Oklahoma Agricultural Experiment Stations have cooperated. Beef cattle were sprayed with 0.5 percent DDT according to the procedure used for controlling livestock pests and subsequently fat samples were taken for analyses. A single spraying caused deposits of 11 to 18 p. p. m. in the fat. Two sprayings produced 31 p. p. m. and 6 sprayings 35 p. p. m. TDE, similarly applied, gave about the same degree of fat contamination. Both insecticides were largely eliminated 6 months after the last spraying. A single spraying with 0.5 percent methoxychlor showed an average of only 2 p. p. m. fat contamination which was not increased by as many as 6 sprayings. Further, methoxychlor residues disappeared within 6 to 10 weeks after treatment. Lindane sprayed at 0.03 percent concentration did not produce detectable levels in the fat during 6 applications at 3-week intervals. Cattle sprayed 36 times with 0.5 percent DDT at 2-week intervals showed no ill effects.

Dieldrin applied as a 0.5 percent spray to dairy cows resulted in excretion of as much as 7 p. p. m. of the insecticide in milk. The insecticide is also readily stored in fat of beef cattle when applied as a spray in concentrations as low as 0.05 percent. Although an excellent insecticide for controlling livestock pests, it probably cannot be recommended because of storage of the insecticide in the fat.

Due to the urgent need for information on storage in animal fat of various insecticides consumed as residues on forage crops following treatment of various field crops for insect control, work on this problem was intensified during the calendar year 1951. Toxaphene and BHC fed to cattle and sheep at 100 p. p. m. in their diet produced no ill effects in a 112-day feeding period. At the end of that feeding, fat contamination was as follows: Toxaphene-fed sheep, 21 p. p. m.; toxaphene-fed cattle, 38 p. p. m.; BHC-fed sheep, 117 p. p. m.; BHC-fed cattle, 250 p. p. m. Experiments are under way with lower levels of toxaphene in the diet since treatment of forage in most circumstances probably would not result in residues as high as 100 p. p. m. Aldrin and chlordane fed at 10 p. p. m. in the diet for 112 days produced no evidence of injury but resulted in fat contamination as follows: Aldrin-fed sheep, 55 p. p. m.; aldrin-fed cattle, 49 p. p. m.; chlordane-fed sheep, 9 p. p. m.; chlordane-fed cattle, 11 p. p. m. Smaller numbers of cattle and sheep were fed dieldrin, aldrin, and chlordane at 25 p. p. m. in the diet for 56 days. The animals did not gain as well as the controls. Fat contamination was

similar for both species of livestock, averaging 78 p. p. m. for aldrin, 72 p. p. m. for dieldrin, and 16 p. p. m. for chlordane. Chlordane residues disappeared after 2 months but aldrin and dieldrin were found in the fat 9 months after insecticide feeding ceased.

There was no evidence of accumulation of methoxychlor in fat of beef cattle fed for 30 days on a diet containing 10 p. p. m. of this insecticide. This insecticide is not likely to create a residue problem in fat of cattle consuming forage treated with the material.

INSECTICIDE INVESTIGATIONS

Best Methods for Residual-Type Spray Applications Studied

Performance requirements were established for applying residual sprays to obtain the best deposition and least contamination of surrounding air. The percentage of deposit was determined by spraying measured quantities of liquid against absorbent paper and weighing the resulting deposit. Particle size was measured by collecting a spray sample on a glass slide and measuring the droplets under a microscope.

When sprays were directed downward practically all spray droplets deposited on the paper. Sprays directed horizontally toward a vertical surface were found to deposit in inverse proportion to the distance between nozzle and surface. The deposit reduced gradually with distance until about a 75-percent deposit was reached. Beyond this the percentage of deposit dropped off rapidly. The deposit was greater when enough spray was released to generate an airstream in the direction of the spray. The distance at which 75 percent or more of the spray deposited was greater with larger droplets, narrower spray angle, or greater output.

It was concluded that for best deposition the distance between nozzle and surface must be limited to that which will allow 75 percent or more of the spray to deposit. For least contamination of surrounding air the mass median diameter of the droplets should be 50 microns or larger to reduce drift to a minimum.

Insecticidal Vapors Utilized in Airplane Disinsectization

A new approach to disinfestation of airplanes was studied during the year using insecticidal vapors. Fiber-glass filters coated with lindane are placed in the air intake ducts of pressurized plane cabins. Vapors given off into the air stream are carried throughout the plane cabin and are lethal to insects. The extremely low concentration is not considered harmful to humans and is not detectable by either crew or passengers. Thorough tests were made in the laboratory before the method was tried on planes. This method requires longer exposure periods than when aerosols are used. Since it is in operation all during the time of flight, it shows considerable promise, and investigations are continuing.

Nerve Ganglia of House Fly Isolated in Insecticide Resistance Studies

A technique has been developed for isolating the nerve ganglia of the house fly, so that direct applications of insecticide can be made. When DDT is applied to the ganglia of susceptible and resistant flies,

the resistant fly shows typical tremors as does the susceptible insect. In the resistant insect the tremors last only a relatively short time, showing that metabolism or some other mechanism has eliminated the symptoms.

New Compounds Tried Against House Flies

An experimental insecticide from industry, now called Pyrolan, was found to be about equal to pyrethrins in knock-down and kill. Two other products of industry, isodrin, a stereoisomer of aldrin, and endrin, a stereoismer of dieldrin, were found to be highly toxic to house flies. Two chlorinated turpentine materials were found to be about one-fifth as toxic at toxaphene.

Studies on scabrin, the insecticidally active ingredient obtained from *Heliopsis scabra*, have been continued. Studies on the effect of five antioxidants on scabrin in oil sprays have been inaugurated. Indications to date are that all these materials are rather effective in the stabilization of this toxicant. Numerous extracts of various parts of *Heliopsis* and *Helianthus* species have been tested in order to determine which fractions contain insecticidally active principals. Synergism was demonstrated for scabrin mixtures with the following pyrethrum synergists: Sulfoxide, piperonyl butoxide, piperonyl cyclonene, *n*-propyl isome, a benzyl propyl ether, and MGK Synergist 264.

TOXICITY OF INSECTICIDES

Dairy Cows Absorb Very Little Insecticide From Treated Alfalfa Hay

Alfalfa hay containing chlordane and toxaphene residues has been fed to dairy cows over a 2-year period. Milk samples were taken every 10 days and analyzed. Results of the analyses did not indicate the excretion in the milk of measurable amounts of these materials. When larger quantities of the insecticides were given in oil solution in capsules or mixed with the feed, analyses indicated that measurable amounts were excreted.

Dairy cows were also fed on alfalfa hay which had been treated with lindane, and samples of milk were analyzed every 10 days. The residue on the hay was very low, so larger amounts were given in oil solution in capsules and mixed with the feed. Benzene hexachloride was detected in the milk samples.

Alfalfa hay containing methoxychlor residues has been fed to dairy cows for long periods. No methoxychlor has been detected in the milk. When considerably larger dosages of methoxychlor were fed in the form of oil solutions in capsules, the insecticide was detected in the milk.

CHEMISTRY OF INSECTICIDES

Allethrin-Related Compounds Synthesized and Tested

A number of compounds related to allethrin were synthesized and submitted for entomological tests. Among these was the compound having a furfuryl group in place of the allyl group in allethrin. This

compound has been referred to as furethrin and has also been synthesized by Japanese chemists. Preliminary tests indicate it is more toxic to houseflies than pyrethrins. As was the experience with allethrin, it is more toxic when made with the natural chrysanthemum monocarboxylic acid than when the synthetic acid is used.

A crystalline isomer of allethrin, isolated previously, was prepared in larger quantity and submitted for insecticidal tests. This isomer, which has been given the name *alpha-dl-trans* isomer of allethrin, while less toxic than allethrin to houseflies, promises to be of value as a standard in the analysis of technical allethrin.

Action of Parathion in Soil Determined

A study of the behavior of parathion in soil indicated that volatilization accounts for the major part of the loss, but that a biological process also operates in its removal.

Insecticidal Properties of Schradan Studied

A procedure was developed for the preparation of pure schradan (octamethyl pyrophosphoramide) for use as a standard in analytical studies. This involved dissolving technical schradan in chloroform, washing with dilute acid and base, decolorizing with charcoal, and distilling a fraction boiling at 118°–124° C./0.5 mm.

Samples of canned peas that had been treated with schradan during their growth were analyzed but no schradan was found in them.

Experiments with chrysanthemums treated with schradan showed that the insecticide seems to concentrate in meristematic tissue and flowers. Study of the rate of penetration of schradan into rose-leaf tissue indicated that about 50 percent of the amount deposited penetrates into the leaves in 6 hours, and the greater part in 24 hours. The schradan then remains in the leaves for several days. When this material was applied to the soil in which tomatoes were grown, it appeared in the fruits in proportion to the amount applied.

Heliopsis Yields Several Toxic Substances

In the investigation of the insecticidal constituents of American species of *Heliopsis*, further quantities of scabrin were isolated from *H. helianthoides* var. *scabra* roots and sent out for testing against various insect species not previously tested with this material. The compound proved to be toxic to mealworms and sawtoothed grain beetles. It was not effective against mustard beetles, cotton stainers, and red flour beetles. In addition to scabrin, an oil toxic to insects was also obtained from this species of *Heliopsis*. The composition of this oil is being further studied.

No Translocation in Tomatoes of Parathion Residues in Soil

Studies were completed during the year of residues accumulating from aerosol and soil applications of parathion to vegetable crops. In these experiments aerosols were applied at the rate of 1 gram of parathion per 1,000 cubic feet in a greenhouse in which tomatoes, cucumbers, and lettuce were growing. Parathion was also added to soil in which tomatoes were grown at rates of 8 to 128 pounds an acre.

To determine whether there was translocation of parathion within the treated plant, clusters of tomatoes were bagged after pollination or when fruits were small. Such bagging eliminated direct contamination by contact with the parathion applied, so that any parathion detected by analysis would have to be by translocation. These fruits contained no significant amount of parathion when harvested. Unbagged fruits on the small plants contained a maximum of 2.36 p. p. m. Parathion was not translocated from treated foilage to bagged tomato fruits nor from treated soil to fruits.

Another phase of this experiment showed that biweekly aerosol applications resulted in a parathion residue on tomato fruits of 2.51 p. p. m. the day after treatment and 0.14 p. p. m. after 14 days. A similar experiment on cucumber showed a residue on the fruits of 0.62 p. p. m. On lettuce the residues ranged from 34 to 97.8 p. p. m. immediately after treatment and fell to 0.7 p. p. m in 17 days in two tests and to 2.0 p. p. m. in 20 days in a third. Sulfotepp residues were somewhat lower than parathion and decreased at about the same rate.

Spray Deposits by Different Applicators Analyzed

In cooperation with the Washington State Department of Agriculture, analyses were made at Yakima of deposits of methoxychlor and lead arsenate applied by several different types of applicators for control of the cherry fruit fly. Hand spray guns and speed sprayers gave deposits in about the same range. Lead arsenate applied as dust either from ground dusters or helicopters gave much lower deposits than sprays. No correlation was found between the quantity of insecticide deposited and the degree of control of the cherry fruit fly.

Persistence of Soil Insecticides Observed

Soil samples from plots at the Irrigation Experiment Station, Prosser, Wash., were also analyzed at Yakima. These were taken in the spring of 1951, a year after treatment with DDT or chlordane. A high percentage of the DDT was still present in the soil but the greater part of the chlordane had disappeared.

DDT Soil Content Increased in Sprayed Orchards

The DDT content of soil in four apple orchards near Yakima has been analyzed for 4 years. The amount of DDT that accumulates in the soil from spray deposits has increased each year.

Insecticidal Residues Analyzed

Insecticidal residue on peaches that had received spray schedules using parathion, DDT, or EPN alone or in mixtures for oriental fruit moth control were determined at Moorestown, N. J. Analyses were made immediately after spraying and at weekly intervals until harvest. The harvest residues of parathion and EPN were only a fraction of a part per million. The DDT residues at harvest were about 7 p. p. m.

Also at Moorestown, analyses were made of methoxychlor and DDT residues on corn leaves sprayed by airplane with commercial emulsions at the rate of 1.5 pounds to the acre in 5 gallons of emulsion.

The first samples were taken soon after spraying, the second samples 8 days later. The deposits of methoxychlor and DDT averaged 5.3 and 7.5 micrograms per square centimeter after spraying and 2.4 and 4.2 micrograms per square centimeter 8 days later.

At Yakima, Wash., numerous analyses were made of residues of DDT, parathion, methoxychlor, EPN, and malathon on apple foliage and fruit samples from experimental plots, immediately after spraying and at intervals thereafter. The same rate of initial deposit and weathering was again obtained for DDT, parathion, EPN, and methoxychlor. Malathon, a more recently introduced insecticide, showed about the same rate of weathering as parathion, 30 to 50 percent of the initial deposit being lost during the first 24 hours after spraying. No malathon was found on the apples at harvest.

In further residue analysis experiments at Yakima it was found that wettable powder suspension sprays gave somewhat higher initial deposits on apples, pears, and peaches than comparable amounts of malathon applied in emulsion form. There was little or no residue at harvest in either case. The residues on peaches were higher initially and weathered off more slowly than on apples or pears.

Ethylene Dibromide To Be Field-Tested for Englemann Spruce Beetle Control

Formulations of ethylene dibromide in emulsions and fuel oil solutions were tested against the Englemann spruce beetle. They showed sufficient promise in small-scale tests to justify larger-scale testing in cooperation with the Forest Service. The resulting control will be compared with that obtained by application of the standard ortho-dichlorobenzene-No. 1 fuel oil solution.

Aerosol Formulations Tested for Licensing

All aerosol formulations proposed during the year by manufacturers for commercial production under United States patent 2,321,023, which is assigned to the Secretary of Agriculture, were examined for chemical compatibility, stability, and insecticidal effectiveness. Approval was issued for 52 of these which met established standards.

Another Aerosol Developed for Greenhouse Use

Experiments with schradan (octamethyl pyrophosphoramide) aerosols for use in greenhouses showed that this insecticide is effective for the control of spider mites and aphids on ornamental plants. Difficulties were encountered with nozzle stoppage in such aerosols because most commercial lots of schradan reacted with the walls of the iron aerosol cylinders to produce a heavy sludge. It was found that this reaction could be eliminated by washing the schradan with dilute sodium bicarbonate solution. All schradan now being supplied by the manufacturers for aerosol use is washed in this way and dried.

Improved Aerosol Valve Designed

An improved type of aerosol valve was designed to incorporate a protective diaphragm that prevents contact of solvents and propellent with the rubber valve parts during storage prior to use. This

eliminates a serious source of valve failure and leakage. This valve is now in commercial production and has been adopted by the Armed Forces.

New Filtering Units for Respirators Developed

With the cooperation of the manufacturers of protective safety equipment, new filtering units for use on respirators were developed. These are effective against mists, dusts, and low-vapor concentrations of TEPP. They are now in commercial production. Units previously found to give satisfactory protection from parathion and nicotine were found also to be effective against EPN, dieldrin, aldrin, and chlordane.

Methods of Dispersing Lindane Vapors Compared

The relative efficiency of various methods of dispersing lindane vapors for insect control was investigated. Animal shelter units were used in these experiments. The methods included use of a carbon dioxide-propelled lindane solution, application of residual water-dispersible lindane spray to walls, a thermal lindane vaporizer, and the blowing of air through lindane-treated filter screens. The maximum lindane concentration found was 17 micrograms in 1,000 cubic feet, regardless of the method of application. The residual spray gave good house fly control until the deposit became covered with dust. To maintain effectiveness, walls and ceilings should be sprayed at 2- to 3-week intervals. Lindane-treated filter screens should be protected by air filters to prevent accumulation of dust. Carbon dioxide-propelled lindane solution applied weekly was efficient. The efficiency of the vaporizer declines noticeably after about 15 days of operation.

Analyses Made of Peanuts Following Cotton Treated With Benzene Hexachloride

A colorimetric method for determination of minute amounts of benzene hexachloride has been developed and satisfactorily adapted to the analysis of soils and peanuts. This method was used in determining the possible occurrence of this insecticide in peanuts grown in soil previously planted to cotton that had been treated with benzene hexachloride to control insects. The work was done in cooperation with the Bureau of Plant Industry, Soils and Agricultural Engineering and the Bureau of Human Nutrition and Home Economics. As little as 5 micrograms of benzene hexachloride can be determined. Samples of peanuts and soils were collected from fields previously planted with benzene hexachloride-treated cotton. Thirty-nine soil samples and 65 peanut samples were analyzed. The peanut samples included those from fields that had received 50 pounds or more of dust containing about 25 percent total benzene hexachloride an acre. In no case was any significant amount of benzene hexachloride found in the samples.

Isolation of Essential Ingredient in Gypsy Moth Lure Attempted

Studies were continued on the isolation and chemical identification of gyptol, the attractant material secreted by the female gypsy moth. This lure has been used widely in trap-surveys for this insect. On

the basis of results obtained in earlier small-scale experiments, isolation of the gyptol was undertaken from the combined, partly purified material recovered from 98,500 abdominal tips of female moths. A product was obtained that was shown to consist of a mixture of gyptol and a closely related substance. A small quantity of gyptol has been obtained in a state sufficiently pure to crystallize.

FOREIGN PLANT QUARANTINE ACTIVITIES

50,000 Unauthorized Airborne Plant Shipments Intercepted

Entry of pests in airborne traffic was prevented through the work of plant quarantine inspectors stationed at 50 airports throughout the continental United States, Hawaii, Puerto Rico, Alaska, and Guam. In cooperation with the United States Customs they inspected aircraft, their stores, quarters, and passengers' baggage for restricted or prohibited plant material that might carry injurious pests. Interiors of planes were examined for living insects that might be present. Airborne cargoes and air mail were also examined. Planes leaving Hawaii for the mainland were given complete plant quarantine clearance prior to departure and sprayed with an aerosol containing DDT to eliminate fruit flies or other pests that might be present as stowaways. This practice was also followed with aircraft leaving Puerto Rico for destinations in the southern part of the continental United States.

During the year 80,000 airplanes, carrying 1,600,000 passengers, were examined by plant quarantine inspectors. These inspections resulted in the interception of 56,577 lots of unauthorized plants and plant products. Much of this material carried insect pests and plant diseases, including such notoriously destructive forms as the citrus blackfly, the oriental, Mexican, West Indian, and Mediterranean fruit flies, the olive fly, the pink bollworm, a bean pod borer, as well as pests of lilacs, grapes, and many other products.

Destructive Pests Intercepted at Ports of Entry

More than 109,000 lots of restricted and prohibited plant material were intercepted in connection with the Bureau's port inspection activities in addition to material taken from airborne traffic. These inspections are designed to prevent the entry of dangerous insect pests and plant diseases by means of ship, train, vehicular, and pedestrian traffic. Thousands of pests, including insects, plant diseases, and nematodes were collected from this huge amount of material. Most of the world's most serious agricultural pests were among those intercepted.

A total of 1,678 importations of plant material were entered through the Hoboken, N. J., inspection house in 1951. Of these, 1,342 lots were fumigated or given some other treatment.

Destructive pests prevented entry into the country with plant material passing through the Hoboken inspection house included nearly 500 lots of insects, plant diseases, and nematodes intercepted there.

An improved system was devised and put into effect for labeling plants being grown under postentry quarantine. This label bears

a permanent legend and contains information helpful in checking the plants while in detention.

On the Mexican border more than 12,400,000 vehicles from Mexico were inspected. This was approximately 2 million more than entered during the preceding fiscal year, which in itself was a record year. This traffic is particularly hazardous because it could be the means of bringing in the citrus blackfly, a pest which was taken from vehicular and pedestrian traffic on several occasions during the year. Maritime traffic was also at a high level. Interceptions of the golden nematode from ships' stores and baggage were made so frequently as to be commonplace.

Plant quarantine protection service was strengthened at a few of the more strategic ports by adding a limited number of inspectors. Steps were taken to improve and strengthen cooperative work conducted in Mexico to prevent the movement of pests of the mainland of that country to the peninsula of Lower California, where they would be within easy reach of California.

Inspection of plant material imported for or under the sponsorship of the United States Department of Agriculture resulted in the interception of weevils imported with chestnuts from Japan, a whitefly on *Anthurium* from Colombia, smuts on sorghum from Nigeria and on wheat and barley from Afghanistan, and scale insects and seed weevils on many occasions from a variety of host materials.

Aditional shipments of returned military equipment were found to harbor the giant African snail. This equipment was cleaned or treated to rid it of these pests.

Australia- and New Zealand-Bound Planes Given Predeparture Clearance at Hawaii

At the request of the Governments of Australia and New Zealand, financial and other arrangements were made whereby plant quarantine clearance is given planes leaving Hawaii for these two countries in order to remove hosts of the oriental fruit fly and destroy any adults that might gain entry into such planes.

Point-of-Origin Inspection of Holland-Grown Bulbs Inaugurated

A team of selected plant quarantine inspectors was sent to The Netherlands during the year to inspect bulbs prior to shipment to the United States. All travel and subsistence costs were paid by the Holland bulb industry. This procedure afforded a far more efficient examination of the bulbs at a considerable saving in funds and manpower. The savings in time and other costs to the industry offset the expenditures made by the exporters. This preinspection also permitted prompt release of shipments upon arrival in this country insofar as plant quarantine requirements were concerned. Since the inspectors worked side by side with representatives of the Netherlands Phytopathological Service in examining the bulbs, that Service had an excellent opportunity to learn our plant quarantine requirements for imported plant material. Furthermore, the inspection at source prevented the arrival of any shipments that had to be refused entry for pest reasons, thus removing the risk of pests escaping while the material was in port. It also prevented loss to United States im-

porters through refusal of shipments, thus permitting them to make commitments with assurance that any bulbs shipped from Holland would be permitted entry here.

Major Revamping of Plant Quarantines and Regulations Under Way

Hearings were held in 1951 affecting 31 plant quarantine orders and regulations. Decisions were reached on actions to be taken on each of these. Legal actions are in progress to amend the respective quarantines in the light of the testimony at these hearings.

Increase in Plants and Plant Products Certified for Export

Certificates to comply with the sanitary import requirements of foreign countries were issued to cover 26,500 export shipments. These covered 10,400,000 containers of domestic plants and plant products going to 114 foreign countries. This was a 30 percent increase over the fiscal year 1951 in export certificates issued. The increase was largely due to increased citrus exports to Europe, flour exports to Venezuela, and wheat exports to Mexico.

Heavily Infested Plane Treated at Honolulu

An incident that occurred at Honolulu illustrates the possibilities of insect spread by means of aircraft. On the evening of May 13, 1952, a B. C. P. A. plane arrived in Hawaii from the Fiji Islands with thousands of leafhoppers aboard. The pilot stated that the plane took off at night from Naudi Airport in a veritable "snowstorm" of leafhoppers. The plane was sprayed with an aerosol bomb several times while in flight. Passengers swatted hoppers during most of the trip. However, numerous hoppers were still alive in the belly of the plane. There were between five and ten thousand live and dead leafhoppers aboard on arrival. Two heavy dosages of agricultural aerosol were applied as soon as the plane landed. The leafhopper was identified as *Perkinsiella vitiensis* Kirk (Delphacidae). This species is the probable vector of the Fiji disease of sugarcane in Fiji and Samoa, a disease not known to occur in Hawaii. It is the opinion of an official of the Hawaiian Sugar Planters' Association that should this disease become established in Hawaii it would probably necessitate a complete change in the production program. The present high-yielding varieties might have to be replaced with low-yielding varieties resistant to the disease.

Spanish Potatoes Found Infested With Golden Nematode

Spanish potatoes arriving at the ports of New York and San Juan were a major problem during the year. Five shipments of 300,000 bags arriving at New York from the Spanish Provinces of Alava, Burgos, Palencia, Leon, and Almeria were released after inspection. Another three shipments of 26,700 bags and 1,500 crates arriving at New York from the Provinces of Valencia and Barcelona were refused entry because they were found to contain cysts of the golden nematode. At San Juan, a shipment of 800 bags of potatoes from the Canary Islands also was found infested with the golden nematode and was

refused entry. Immediately upon confirmation by specialists of the identity of the nematodes, permits authorizing the importation of potatoes from Spain and the Canary Islands were suspended.

TRANSIT INSPECTION

Transit inspection of domestic mail was coordinated with the inspection of foreign mail during the year. As a result both activities were broadened and strengthened. The new arrangement permits more effective utilization of manpower. It permits the performance of foreign mail inspection at several points formerly manned only by transit inspectors. Foreign and domestic mail inspection was resumed after a lapse of several years at Omaha, Nebr., an important center for both of these activities.

During the year, more than 1,166,545 shipments were examined at the 18 stations where transit inspection was conducted. Inspectors found 1,169 shipments that were moving contrary to the major Federal or comparable State quarantines. Another 3,148 shipments failed to comply with District of Columbia plant regulations or quarantine or nursery inspection requirements of the States.

Foreign mail inspected upon arrival in the United States was found to contain such destructive pests as the golden nematode, the olive fly, citrus canker, and another disease of citrus, *Phoma citricarpa*. Hundreds of packages of shamrocks from Ireland intercepted in the mails were fumigated to kill cysts of the golden nematode.

JAPANESE BEETLE

Trap-Scouting Detects Beetle Spread

Surveys to detect spread of the Japanese beetle continued with traps set in 1,700 communities in 36 States outside the infested area. One beetle was taken for a first-record collection in Los Angeles, Calif. The site at which this beetle was collected and 5 acres surrounding it were treated with chlordane shortly after the discovery. An established infestation in South Bend, Ind., was discovered. Foliage was sprayed with DDT and soil surface treatments with DDT or chlordane were applied to 184 acres in this locality. In addition, State quarantine regulations were issued covering the South Bend infestation. There were other significant beetle collections in New York and in a number of Midwestern and Southern States adjacent to regulated areas.

Regulated Area Extended to Include Established Infestations

Following the 1951 survey season, regulated areas were extended, effective August 14, 1951, in four of the quarantined States and North Carolina was placed under Federal quarantine for the first time. Also, effective June 4, 1952, further amendments added additional territory to the regulated areas in New York, Ohio, Virginia, and West Virginia. They also established a procedure for restricting the movement of regulated articles to an isolated regulated area when it has been determined that such movement presents a hazard of spreading Japanese beetle infestation.

Airplanes Treated to Destroy Hitchhiking Beetles

As part of the broad campaign to prevent spread of the beetle by airplane, more than 3,000 residual DDT plane treatments were applied at 31 airfields. Some 12,000 aerosol applications were made in planes at 52 fields. Cooperative DDT foliage treatments at 22 military and commercial airfields totaled 48. More than 2,000 beetles were removed from passengers' baggage and clothing at 7 airfields. In addition, 1,135,000 beetles were taken in traps operated at 42 airfields in the infested area.

Cooperative Bureau, military and commercial airline tests to develop suitable aerosol space treatments to kill the Japanese beetle in airplanes was advanced this spring by the use of a new type of container. This is filled with the regular DDT-pyrethrum and is fitted with special valves. The container is nonrefillable and more economical than those previously used. A quantity of such containers was obtained from a commercial filling company on an experimental basis.

Huge Quantities of Plant Material Certified

During 1951 there were moved under quarantine certification to all parts of the United States and Canada approximately 142,000,000 plants, 1,300,000 pounds of soil, 250 refrigerator carloads and 800 truckloads of fresh fruits and vegetables. The estimated value of these items is approximately $15,000,000.

Extensive Foliage and Soil Treatments at Isolated Infestations

During the spring of 1952 cooperative State-Federal soil foliage treatments were applied to seven beetle collection locations outside of Federal regulated areas in Georgia, Illinois, Indiana, Kentucky, and West Virginia. One hundred and twenty-three acres were surface soil treated with chlordane in five localities in West Virginia as a part of the State's Japanese beetle retardation program.

Japanese Beetle Soil Treatments Effective for Many Years

The studies of numerous materials for controlling grubs of the Japanese beetle in the soil have been continued in the laboratory at Moorestown, N. J. Toxaphene was found to compare very favorably with DDT for the control of Japanese beetle grubs in turf. An application of this material at the rate of 25 pounds per acre in 1947 was found to be still effective in eliminating grubs in 1951. During the same period TDE has been consistently less effective than DDT. Preliminary laboratory tests of lindane gave inconsistent results. Heptachlor, 2 pounds an acre, compared favorably with dieldrin and chlordane at the rate of 3 and 10 pounds an acre, respectively, in killing grubs in soil. Endrin was equivalent to dieldrin in toxicity to Japanese beetle grubs, while isodrin was much more toxic than dieldrin.

A 4-year study of the effect of DDT in the soil upon the growth of grass, rye, soybeans, and corn, concluded in 1951, showed that DDT up to 60 pounds per acre had no deleterious effect on the grass or the

field corn. The 60-pound treatment caused a slight reduction in the average green weight of the soybeans, and both the 25- and 60-pound treatments caused slight reductions in the average green weights of the rye. In the same 4-year study chlordane at rates up to 19 pounds per acre and, over a 3-year period, aldrin at 3.2 pounds and dieldrin at 2.9 pounds per acre had no deleterious effect on any of the foregoing crops. In field tests at widely separated points DDT applied in 1944 at the rate of 25 pounds per acre to turf continued to give complete protection through 1951. The oldest treatment has shown no change in effectiveness during the 7⅓ years following application. This was in spite of the fact that the quantity in the soil had dropped more than two-thirds.

DDT and Other Insecticides Gradually Lost From Soils

DDT does not remain indefinitely in the soil after being applied for Japanese beetle control. Studies by the Moorestown, N. J., laboratories of turf plots maintained at a number of locations from Massachusetts to New Jersey have shown that after a few years it disappears fairly fast. The average carry-over of DDT after 2 years was 92 percent; after 4 years, 43 percent; after 6 years, 36 percent; and after 7 years, 29 percent.

Chlordane decreased more rapidly than the DDT—to 30 percent of the amount applied in 1½ years whereas more than this percentage of DDT still remained after 6 years. After 40 months, 46 percent of the toxaphene and 44 percent of the TDE remained, and after 12 months 67 percent of the dieldrin and 33 percent of the aldrin.

WHITE-FRINGED BEETLES

Surveys Show Annual White-Fringed Beetle Spread

By the end of 1951 white-fringed beetles were known to occur in 143 counties in 8 States. During the year infestations were found for the first time in Lauderdale County, Miss.; Darlington and Florence Counties, S. C.; and Tipton County, Tenn. In these 143 counties, 340,000 acres have been determined as infested. As a result of the control program no beetles could be found in 1951 on 12 percent of this acreage. Light infestations are present on 68 percent, moderate numbers on 13 percent, and heavy infestations on only 7 percent. In 17 of the previously known infested counties, no specimens of beetles can be found. During 1951, more than 200,000 certificates and permits were issued authorizing the movement of host material.

Wide Cooperation in Controlling White-Fringed Beetle

During the year contributions for white-fringed beetle control by the States, counties, municipalities, industrial concerns, and other establishments and individuals approximately equalled Federal expenditures for this purpose. These contributions represented a large increase over previous years. They were the direct result of efforts by the Bureau to bring about a more equitable distribution of the workload among those benefiting from the control program.

Excellent results have been obtained in controlling white-fringed beetles since DDT was introduced. Since 1946 approximately 50,000 acres of agricultural land have been soil-treated with 10 pounds of DDT to the acre. The residual effects of the insecticide are expected to remain for at least 3 years. Since 1948 more than 2,500 acres of nursery land have been soil-treated at the rate of 50 pounds of DDT an acre. This treatment assures destruction of beetle larvae in the soil and allows the movement of nursery plants from such land to non-infested localities without further treatment.

Use by farmers of DDT in fertilizers to replenish the DDT residue in farm land treated in previous years was authorized in the spring of 1951. This was too late to obtain maximum results in 1951 since a large part of the commercial fertilizers had been mixed before that date. However, some 600 tons of commercial fertilizers containing 0.5 percent DDT were used during the year for this purpose.

Soil Insecticides Give Effective White-Fringed Beetle Control

Foliage applications of approximately 10 pounds of toxaphene an acre for control of cotton insects during a single season have provided excellent control of white-fringed beetle larvae in the soil for the following 2 years. DDT mixed with the soil at 25 pounds an acre gave a complete kill of newly hatched larvae for 5 years after application and 98 percent kill the sixth year. The application of 50 and 100 pounds to the acre gave complete control for the sixth year. Other insecticides that continue to look promising when used as soil treatments to destroy the larvae are chlordane, toxaphene, aldrin, dieldrin, and heptachlor. This work was in cooperation with the Alabama State Department of Agriculture and Industries and the Florida State Plant Board.

Cultural Practices Fail To Influence Beetle's Development

Studies of the development of the white-fringed beetle as related to cultural practices showed that the addition of stable and green manure to the soil for 2 years did not cause any appreciable change in the time of adult emergence or in the survival of immature larvae in either 1950 or 1951.

NEMATODES INFESTING POTATOES

Cyst Forming Nematode Found on Tobacco

A significant development during the year was the reporting of a species of *Heterodera* on the roots of tobacco in the State of Connecticut. A cooperative Federal-State soil survey conducted in Connecticut revealed infestation on four properties, three of which were growing shade tobacco and one potatoes. Specimens submitted to the Division of Nematology, Beltsville, Md., were found to be morphologically indistinguishable from *Heterodera rostochiensis*. This infestation is particularly important since tobacco varieties have been tested for susceptability of *Heterodera rostochiensis* with negative results. Research workers are investigating the host range of this tobacco cyst nematode.

Croplands Surveyed for Golden Nematode

The golden nematode program continued to provide for a systematic field survey of all croplands within and near the quarantined areas of Nassau and Suffolk Counties, Long Island, N. Y. Lands surveyed during the year on Long Island totaled 33,700 acres, from which 57,000 soil sample lots were collected. Golden nematode infestations were found for the first time on 962 additional acres bringing the total known infested acreage of Long Island to 10,760. Of this, 3,800 acres have been removed from agricultural usage by housing and industrial developments, thus leaving 6,960 acres of agricultural land infested. The new infestations found during this year were all confined to Nassau and western Suffolk Counties except for one isolated infestation on the north fork of eastern Suffolk County near the town of Cutchogue. In addition to the surveys of croplands, inspections were made of 300 nurseries and retail plant sales establishments in Kings, Nassau, Queens, and western Suffolk Counties. These surveys resulted in the finding of 8 such establishments infested with the golden nematode, making a total of 92 to date. The program to treat these establishments with D-D (dichloropropane-dichloropropene) was continued. A total of 33 infested nurseries were treated during the year. Surveys were made in cooperation with 15 States. In all, 69,000 samples were collected representing nearly 217,000 acres.

A cooperative Federal-State survey of potato- and tomato-growing areas in California has been completed. Nearly 23,000 soil samples were collected from potato graders, storage sites, and potato and tomato fields in 26 counties. These samples are representative of more than 88,000 acres of cropland. Laboratory processing of these samples was completed without finding any evidence of the golden nematode.

Compensation Paid for Acreages Withheld From Host Crop Production

A compensation program designed to prevent the increase and spread of the golden nematode by withholding infested acreage from host crop production was continued during the year. A total of 1,215 acres of infested land was withheld from production. The Federal and State of New York governments shared equally in the payment of $97,179 compensation to farmers. This program provides payments only to owner-operators of infested properties. The payment of compensation to renter-operators for withholding lands from production was discontinued by the State of New York in 1951.

Improved Device for Detecting Nematodes in Soil

A more efficient soil-washing machine has been developed to separate golden nematode cysts from soil taken from potato fields suspected of being infested. Designed in cooperation with the Toledo, Ohio, laboratory of the Bureau of Plant Industry, Soils, and Agricultural Engineering, this machine is lightweight and portable and operates at a lower cost and with greater efficiency than similar equipment available heretofore.

CONTROL OF PLANT DISEASES

White Pine Forests Protected Against Blister Rust

Blisterrust now controlled in over half of infested areas

Cooperative work to protect existing white pine forest resources from destruction by the white-pine blister rust continued on approximately 26 million acres of Federal, State, and privately owned forest land. The disease has been controlled on 58 percent of this acreage. Work necessary to maintain this condition was given preference over the initial eradication of ribes in other areas. Partial control of the disease has been accomplished in an additional 36 percent of the control acreage.

The areas of these control operations include 4⅕ million acres of National Forest lands; nearly 600,000 acres of National Park, O&C Revested, and Indian lands under supervision of the Department of the Interior; and 21¼ million acres of State and private forest lands.

Under technical direction, by the Bureau, cooperating State, local, and other Federal agencies destroyed 14½ million ribes on 1¼ million acres of control area during 1951. More than 300,000 of these acres received their initial coverage; the remaining areas were reworked to maintain control of the rust. Of the total acreage, the United States Forest Service removed ribes from 165,000 acres, the Department of the Interior from 57,000, and the Bureau working with cooperating State and local agencies from slightly more than 1 million acres. Cooperating States, counties, townships, and private agencies provided approximately $718,000 for this work for the fiscal year 1952. This was an increase of $34,000 over the previous year.

Technical services, along with over-all leadership, planning, and coordination were rendered through Bureau workers to cooperators carrying on field operations on white pine lands in 27 States. More than 3,000 seasonal workers were employed in these operations. Most of these workers were quartered in 60 forest camps in remote forest areas. In the sugar pine area, the Bureau recruited and screened laborers for National Park Service and Forest Service camps. About 250 men were selected and assigned to the various field operations.

Bureau personnel assisted the Forest Service in the latter's preparation of a project work inventory for blister rust control in the Columbia Basin Comprehensive Agriculture Plan.

This year's activities have contributed effectively to the long-time program for protecting white pine forests from blister rust attack and assuring a future supply of this valuable timber.

Power sprayers adapted for use in remote areas

Among technical services rendered, progress was made in adapting power spraying equipment for use in remote forest areas. By mounting such equipment on 6 x 6 trucks it was possible to use it at great savings in situations previously inaccessible.

Another improvement in spray equipment is a lightweight sprayer for basal stem treatment of ribes with oil-2,4-D or oil-2,4,5-T concentrates.

Still another improvement in spray equipment is a lightweight sprayer now being used to spray concentrated herbicides on the stems

of ribes plants near ground level. These concentrates are either oil-2,4-D or oil-2,4,5-T. Dosages, diluent, and markers to show areas sprayed were further studied to lower costs and improve the effectiveness of this work.

Of many markers tested, a commercially made scarlet dye used at the rate of a tablespoonful of dye per gallon of herbicide proved to be the brightest and most light-fast. This indicator speeds the work of crews using this method and assures thorough coverage of individual bushes. It proved very effective in treating ribes in remote, rugged terrain in both Rocky Mountain and Sequoia National Parks.

Encouraging results with defoliants

Continuation of the previous years' ribes-defoliation tests showed that three spray applications of 2,4-D at a low dosage of 50 p. p. m., using about 3 ounces of the acid per acre, gave nearly complete kill of *Ribes roezli*.

Encouraging results obtained in destroying ribes and associated brush in western pine areas by broadcast spraying with 2,4,5-T has renewed interest in the seed tree method of pine management whereby certain trees are selected for seed production and regeneration of the stand. The Bureau therefore expanded its plot studies on the selective toxicity of 2,4,5-T to white pine as well as associated ribes and brush. Further work is contemplated to improve broadcast methods for ribes suppression by aircraft, mist blower and power sprayer, especially with repeated low dosage applications of herbicides that selectively damage ribes.

Antibiotics tested against blister rust cankers

Actidione, an antibiotic, in mixture with 2,4,5-T has proved of sufficient toxicity to blister rust cankers in infected trees to warrant further field tests.

Additional rust-resistant pines found

Seven additional white pines that are apparently rust-resistant were found during the year, increasing to 66 the number of available rust-resistant trees. Several apparently rust-resistant sugar pine trees were located in northern California. Scions from these trees were successfully grafted on seedling stock.

As part of these studies, five test plantings of grafted and seedling western white pines were established in northern Idaho. Seed was also collected and extracted from trees in which pollination was controlled in 1950. These seeds will be used to produce F_1 progeny starting in 1952. Of 93 crosses attempted in 1950, 85 produced normal-appearing seed, with 78 crosses yielding seed in quantities adequate for progeny testing.

Blister rust spread determined

White pines infected with blister rust were observed for the first time in Avery County, N. C.; Morgan County, Tenn.; Botetourt, Bedford and Warren Counties, Va.; and Raleigh and Morgan Counties, W. Va.

With discovery of blister rust in Calaveras County, Stanislaus National Forest, Calif., the known southward range of the rust on

sugar pine in the Sierra Nevadas was extended 13 miles. This newly discovered infection contains 310 cankers in 77 trees. It apparently became established there in 1944. Rust infection on pine is now nearly 250 miles south of the Oregon-California border.

Blister rust also was found east and south of previously known limits of spread in the Rocky Mountain region. An infected white-bark pine was found on Carnelian Creek on the edge of the Mount Washburn control unit in Yellowstone National Park. Infected pines were also found for the first time in Powell County, Mont., and Adams County, Idaho. Ribes containing blister rust infection were found for the first time in Fergus and Wheatland Counties, Mont., and Big Horn County, Wyo.

Barberry Eradication to Control Stem Rust

Broad areas freed of barberries

Black stem rust infection in grains was light in 1951, with damage confined chiefly to crops growing near barberry bushes.

Barberry eradication for the control of this rust continued in cooperation with the States of Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Montana, Nebraska, North Dakota, Ohio, Pennsylvania, South Dakota, Virginia, Washington, West Virginia, Wisconsin, and Wyoming.

State Departments of Agriculture, County Boards of Supervisors, the Extension Service, and the Agricultural Experiment Stations in the 18 States where eradication activities are performed were the principal cooperators in this work. Landowners furnished labor and materials in many instances. The value of funds and services contributed by cooperating agencies exceeded $262,000.

Eradication work was concentrated principally in areas where barberry bushes had previously been a factor in spreading rust. Initial work was done in Missouri, Pennsylvania, Virginia, West Virginia, and Washington.

These operations resulted in the destruction of nearly 14½ million barberry bushes on 1,500 new and 2,000 reinfested premises in 324 counties. Twenty-five percent of the properties reworked showed new growth. Eight thousand former barberry sites were rechecked, 3,600 of which received their final reinspection. Some reseeding had occurred from fruiting bushes on 65 percent of the properties. Survey crews engaged in this work covered 24,200 square miles. Areas totaling 22,000 square miles were placed in a maintenance status, and in the future will require only sufficient work to maintain them in a barberry-free condition.

Wind-spread of rust spores traced

Slide-exposure stations located in 27 States helped to chart the movement of wind-borne stem-rust spores during the growing season. Physiologic-race surveys showed race 15B of wheat stem rust is widely distributed and well established as far south as central Mexico. Race 7 of oat stem rust is also widely distributed. More than 1,100 collections of stem rust from grain and barberry were examined at the Federal Rust Laboratory at the University of Minnesota, St. Paul, Minn. From United States collections, race 15B was isolated from

56 percent of nearly 700 wheat collections. This race comprised 40 percent of the nearly 1,000 isolates. Race 15B was followed in order of prevalence by race 56 (26 percent), race 38 (9 percent), and race 17 (9 percent).

Race 15B was detected in stem rust collections made from Texas and Mississippi northward to Wisconsin, Minnesota, and North Dakota. Twenty-seven races were isolated from rusted grain, including a number of unusual ones that came principally from barberry-infested areas. Race 11, widely prevalent a few years ago, was found in 9 States. This race is of particular interest, since it is especially virulent on certain varieties that are being used as parent stock in a cereal breeding program. From 404 uredial collections of oat stem rust, 430 isolates comprising 8 races were obtained. Race 7 was the most abundant followed by races 8 and 12, respectively. Races 5, 6, 10, 12, and 13 were also found. Race 6, a race that at high temperatures attacks varieties with the Hajira type of resistance, was found only once. This variability of races found in barberry-infested territory this year again demonstrates the major importance of the barberry as a hybridizer of a large variety of rust races.

New chemicals tested against barberries

Test plots in Colorado, Pennsylvania, and Virginia provided information on the effectiveness of new chemicals and new combinations of old formulations on both native and common species of barberry. Tests in Colorado showed that 2,4-D as a foliage spray is as effective as a mixture of 2,4-D and 2,4,5-T on *Berberis fendleri*. The 2,4-D was adopted for field use, resulting in a reduction in eradication costs of $11.20 an acre.

Two chemicals,, MCP (2-methyl, 4-chlorophenoxyacetic acid) and a formulation of 2,4-D, 2,4,5-T with a penetrant, appear to be effective on *B. vulgaris*. These are the first formulations of hormone-type chemicals that have given a good kill of this species. These formulations will be tested in the field in 1952. Hormone-type chemicals now used in the field on native species of barberry continue to give satisfactory results in field programs. The cost of the chemical used in a unit area has been reduced about 60 percent as compared to the older sodium chloride and chlorates applications.

Six million barberry plants certified for movement

Enforcement of the quarantine on the interstate movement of barberries, mahonia, and mahoberberis required the inspection of nearly 300 nurseries. Permits for shipment of approved stock were issued to 68 dealers in 41 States. Varieties of Japanese barberry made up the greater part of stock inspected in the field. Six million plants of this species were approved, 3½ million greenleaf and 2½ million redleaf. Approval was withheld from 5½ million *B. thunbergi* that did not meet the 2-year-old-stock requirements, from 230 plants still undetermined as to susceptibility to stem rust, and from 60,000 2-year-old plants presumably of this species that did not conform to type.

Organization changes were made in 1951 to reduce overhead costs and to improve administration of this work. Eight States were combined into four areas, with consequent reduction in supervisory and clerical personnel. Three State offices were closed.

Extensive educational activities acquaint public with rust control methods

Barberry eradication and the stem-rust control program were discussed informally at a wide variety of farmer, civic, school, and professional group meetings—331 in all. Radio scripts were prepared and 85 broadcasts presented over 25 stations as a part of the stations' regular agricultural programs. Cooperating States continue to use the press to keep the public informed of eradication work and its progress. Several daily papers and farm magazines featured the stem-rust control program in articles that emphasized the importance of the new rust races.

Copies of the color-sound film, "Stem Rust—Airborne Enemy of Grain," were placed in all of the important agrcultural free-loan film libraries in the 18 cooperating States. There are now 50 copies of the film in general use. This year the film was shown to 800 groups.

Two new small exhibits for use at fairs and crop shows were built this year. These and eight other exhibits were in general use at State and county fairs, crop and weed shows, and in the windows and lobbies of public buildings.

General Decline in Peach Mosaic Infection

A survey during 1951 in the peach mosaic infected States of Arkansas, California, Colorado, Oklahoma, Texas, and Utah resulted in the finding of 5,219 peach mosaic trees among the 3,300,000 trees inspected, or a disease incidence of 0.16 percent. This continued the general annual decline in mosaic from the peak year of 1935, when an incidence of 4.16 percent was observed. Erath and Fannin Counties, Tex., have been found free of the disease for three successive years and were released from State quarantine regulations in 1951.

More Grower Participation in Phony Peach Control

Nearly 6 million peach trees were inspected for phony peach infection in the States of Alabama, Arkansas, Georgia, Florida, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, and Texas. This virus disease is the most serious disease of the peach in the Southeastern States. The inspections were made on 37,000 properties in 118 counties. This resulted in the finding of 116,689 phony trees on 963 properties, or a disease incidence of 2 percent. A survey was also made in Virginia but no disease was found there.

In the heavily infected phony areas of Alabama and Georgia, growers participated to a greater degree than in past years by furnishing labor to delimb phony trees, to remove stumps of diseased trees, and to destroy wild plums growing near orchards. Disease incidence in this area showed an increase in 1951 over the preceding year.

All nurseries in the phony peach infected area qualified for certification of the host stock on their premises. Fifty-four nurseries and dealers in the peach mosaic infected areas of Arizona and New Mexico, containing 7,800 trees, were found ineligible for certification. More than 1.7 million trees in 264 nurseries were determined as eligible for certification to any destination.

Life History of Phony Peach Vectors Determined

Life history studies were made to determine the seasonal development of the insects that transmit phony peach and to obtain information as to their habits. It was learned that two species, *Homalodisca triquetra* (F.) and *Oncometopia undata* (F.), have two full generations annually and a partial third. *Cuerna costalis* (F.) has three full generations. *Graphocephala versuta* (Say) has four. The two species known to be natural vectors are those exhibiting the slowest development. *O. undata* appears to be more prevalent on peach trees in spring, while *H. triquetra* predominates during the late summer and fall. The latter species, apparently the primary vector, occurs in greatest numbers in late June and July. Present evidence is that it does not feed on peach trees to any extent at that season. The information on life history and seasonal behavior is being used to determine the proper scheduling of spray applications.

AIRCRAFT AND SPECIAL EQUIPMENT CENTER

By centralizing aircraft and special equipment used for demonstrating improved pest control procedures at the Bureau's Aircraft and Special Equipment Center, Cimarron Field, Okla., provision has been made for coordinating the Bureau's interest in this general field.

The Bureau has taken full advantage of work carried on by State, private and other Federal agencies that can contribute technical information on methods of applying insecticides with efficiency and safety. This has allowed the closing of Bureau-operated automotive and mechanical shops and a reduction of personnel assigned to such work. Maintenance and repair work required on regular automotive equipment is now done on a contract basis.

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